PEARL

The Journal of HEREDITY

"STAR-HALO" PHLOX

(SEE PAGE 183)

"Taste-Blindness" and Race — *Soda Straws for Plant Hybridists*

Cull Cows for Proving Gene-Constitution of Sires

A New Dwarf Maize — *A Mutational Theory of Cancer*

Venezuela "Septuplets" Had Different Birthdays

Inheritance in Toy Griffons — *Creeper - Single Comb Genes Linked*

VOLUME 25 MAY, 1934 NUMBER 5

The American Genetic Association

An incorporated organization devoted to promoting a knowledge of the laws of heredity and their application to the improvement of plants, animals, and human racial stocks

DAVID FAIRCHILD, President Vice-President, W. E. CASTLE Secretary, C. E. LEIGHTY

Treasurer, J. H. KEMPTON

Legal Advisors, PEELLE, OGILBY and LESH

EDITORIAL BOARD

Managing Editor, ROBERT C. COOK

M. DEMEREC R. R. GRAVES L. C. DUNN

H. J. MULLER GEORGE M. DARROW PAUL POPENOE

Members of the Council are ex-officio members of the Executive Board

COUNCIL

W. E. CASTLE, Professor of Genetics, Harvard University, and Research Associate of the Carnegie Institution of Washington.

LEON J. COLE, Professor of Genetics, University of Wisconsin.

G. N. COLLINS, Botanist, U. S. Department of Agriculture, Washington, D. C.

O. F. COOK, Bionomist in Charge of Breeding Investigations, U. S. Department of Agriculture.

DAVID FAIRCHILD, Agricultural Explorer, U. S. Department of Agriculture.

HARRY V. HARLAN, Senior Agronomist in Charge of Barley Investigations, U. S. Department of Agriculture.

SAMUEL J. HOLMES, Professor of Zoology, University of California, Berkeley, California.

C. E. LEIGHTY, Agronomist in Charge of Eastern Wheat Investigations, U. S. Department of Agriculture.

N. D. C. LEWIS, Chief Medical Officer, St. Elizabeth's Hospital, Washington, D. C.

J. H. KEMPTON, Bureau of Plant Industry, U. S. Department of Agriculture.

E. W. SHEETS, Chief of Animal Husbandry Division, U. S. Department of Agriculture.

SEWALL WRIGHT, Professor of Zoology, University of Chicago.

ADVISORY COMMITTEE

W. S. ANDERSON, Genetics Department, University of Kentucky, Lexington, Kentucky.

E. B. BABCOCK, Genetics Department, University of California, Berkeley, California.

E. A. BESSEY, Professor of Botany, Michigan State College, East Lansing, Michigan.

A. F. BLAKESLEE, Plant Genetist, Carnegie Institution, Cold Spring Harbor, New York.

J. K. BREITENBECHER, McGill University, Montreal, Canada.

W. E. BRYAN, Professor of Plant Breeding, University of Arizona, Tucson, Arizona.

C. B. DAVENPORT, Director, Department of Genetics, Carnegie Institution of Washington, Cold Spring Harbor, L. I., New York.

J. A. DETLEFSEN, Professor of Genetics, Wistar Institute, Philadelphia, Pennsylvania.

RUSSELL W. DUCK, Professor of Animal Husbandry, Syracuse University, Syracuse, New York.

E. M. EAST, Professor of Plant Genetics, Bussey Institute of Applied Biology, Boston, Mass.

R. A. EMERSON, Professor of Plant Breeding, Cornell University, Ithaca, New York.

C. P. GILLETTE, President, The Genetic Foundation, Fort Collins, Colorado.

C. M. GOETHE, Sacramento, California.

HARRISON R. HUNT, Professor of Zoology, Michigan State College, East Lansing.

H. S. JENNINGS, Professor of Zoology, Johns Hopkins University, Baltimore, Maryland.

D. F. JONES, Plant Breeder, Connecticut Agricultural Experiment Station, New Haven, Conn.

M. A. JULL, Senior Poultry Husbandman, U. S. Department of Agriculture, Washington, D. C.

F. B. LINFIELD, Director, Montana Experiment Station, Bozeman, Montana.

C. C. LITTLE, Director, Roscoe B. Jackson Memorial Laboratory, Bar Harbor, Maine.

JAY L. LUSH, Professor in Animal Husbandry, Iowa State College, Ames, Iowa.

H. H. Newman, Professor of Zoology, University of Chicago, Chicago, Ill.

T. S. PALMER, Expert in Game Conservation, U. S. Dept. of Agriculture, Washington, D. C.

JOHN H. PARKER, Professor of Agronomy, Kansas State College, Manhattan, Kansas.

JOHN W. SCOTT, Professor of Zoology, University of Wyoming, Laramie, Wyoming.

A. D. SHAMEL, Physiologist, U. S. Department of Agriculture, Riverside, California.

GEORGE H. SHULL, Professor of Biology, Princeton University, Princeton, New Jersey.

EDMUND W. SINNOTT, Professor of Zoology, Barnard College, Columbia University, New York City. (Representative of A. G. A. on Council of Amer. Assoc. for the Advancement of Science.)

W. W. SMITH, Professor of Animal Husbandry, Purdue University, Lafayette, Indiana.

CHARLES R. STOCKARD, Professor of Anatomy, Cornell University, New York City.

A. B. STOUT, Director of Laboratories, New York Botanical Gardens, New York City.

W. T. SWINGLE, Plant Physiologist in Charge of Breeding Investigations, U. S. Department of Agriculture, Washington, D. C.

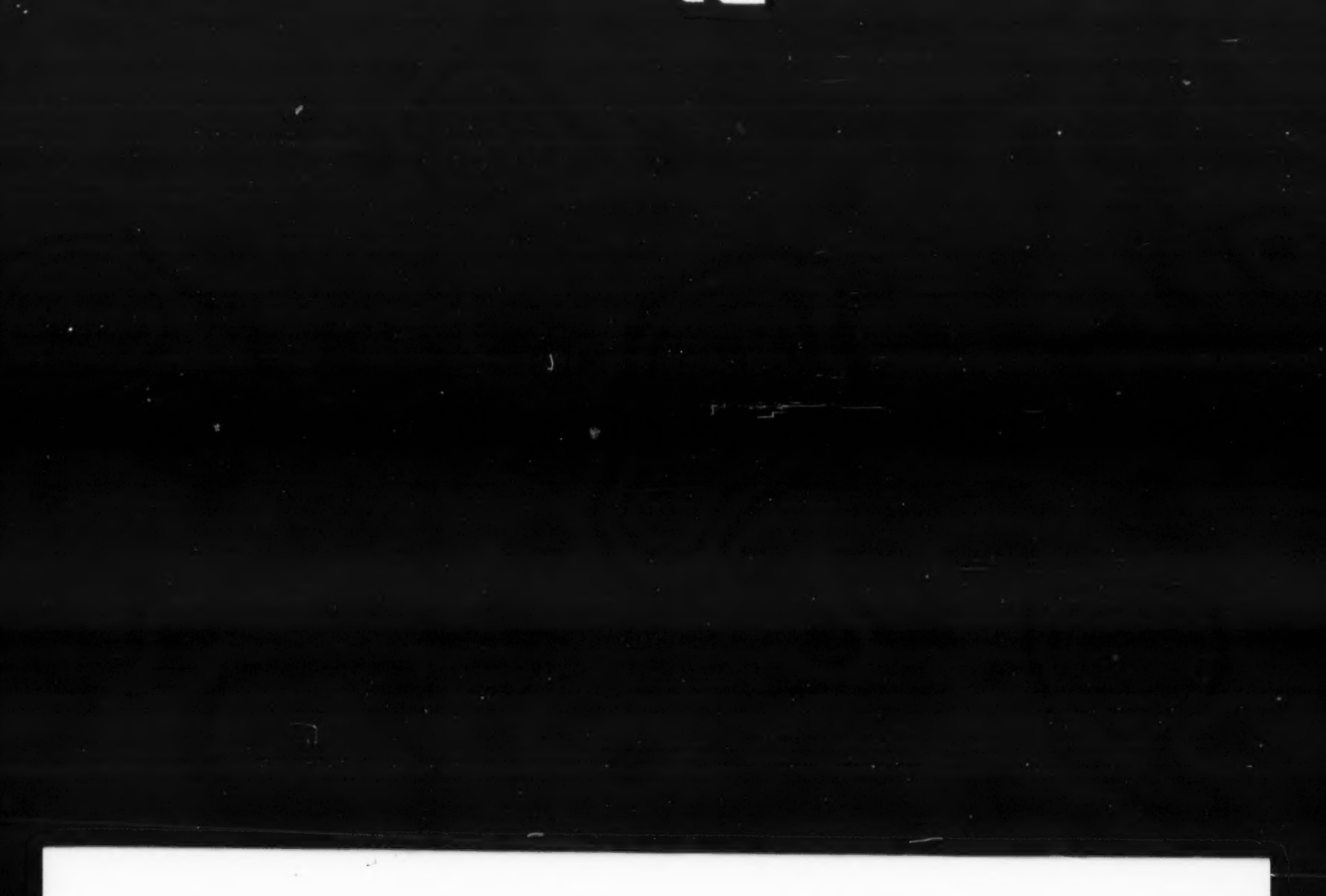
W. H. TOMHAVE, American Aberdeen-Angus Breeders' Association, Chicago, Ill.

H. E. WALTER, Professor of Biology, Brown University, Providence, Rhode Island.

H. J. WEBBER, Prof. Subtropical Hort., Citrus Experiment Station, Riverside, California.

E. N. WENTWORTH, Armour's Bureau of Agr'l Research and Economics, Chicago, Illinois.

P. W. WHITING, Station for Experimental Evolution, Cold Spring Harbor, Long Island, N. Y.



The

Journal of Heredity

Vol. XXV MAY, 1934 No. 4

IN THIS ISSUE

ORIGINAL ARTICLES

A Dairy Sire Progeny Test
By B. L. Warwick and O. C. Copeland.... 177

The "Eye" of Phlox
By J. P. Kelly.... 183

Taste Blindness and Race
By Leland W. Parr.... 187

Heritable Characters in Maize
By William H. Eyster.... 191

Inheritance in Toy Griffons
By C. C. Little.... 198

A New Technique in Cotton Hybridizing
By Clifton C. Doak.... 201

Creeper and Single-Comb Linkage in the Fowl
By Lewis W. Taylor.... 205

REVIEWS AND NOTES

Pediatrics and Genetics.... 186

A Mutational Theory of Cancer.... 190

"Septuplets" with Different Birthdays.... 193

Errata in March Journal.... 200

Relief Families Larger than Average.... 200

COMING

The Eugenic Views of Jefferson and Adams

The champion of political equality of man was under no illusions that such equality also applied to innate endowment. Jefferson recognized "a natural aristocracy among men * * * as one of the most precious gifts of nature. . . ."

Drosphila Are Tolerant of Alcohol

A concentration of less than 1% of ethyl alcohol in human body tissues produces unconsciousness, but the fruit fly is able to prosper on a medium containing 20 times as much, or on a concentration of wood alcohol fatal to mammals—a striking example of adaptation to environment.

An Inbred Herd

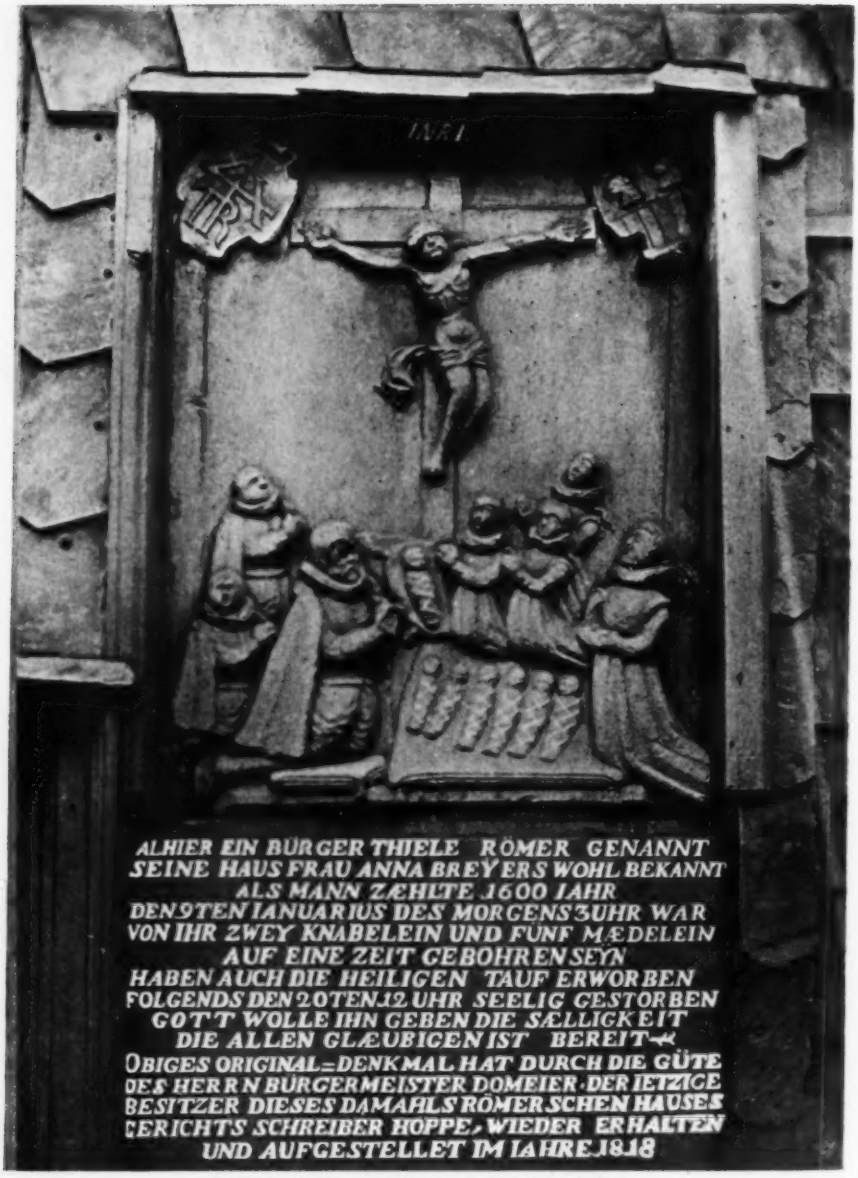
Twenty years of cattle breeding without new blood, with plenty of show-ring prize winners in the fifth generation.

Tetraploid Tomatoes From a Triploid

Unusual reproductive behavior, perhaps the exception to prove a rule.

The JOURNAL OF HEREDITY is published monthly by the AMERICAN GENETIC ASSOCIATION, at 1918-1932 Harford Avenue, Baltimore, Md., and Victor Building, Washington, D. C. Address all communications regarding editorial matters and the business management of the Association to Room 510 Victor Building, Washington, D. C. Entered as second-class matter February 24, 1923, at the postoffice at Baltimore, Maryland. Acceptance for mailing at the special rate of postage provided for in Section 1103, Act of October 3, 1917, authorized December 30, 1918. Contents copyrighted 1934 by the American Genetic Association. Unauthorized reproduction of material from THE JOURNAL not permitted. The title "Journal of Heredity" is registered as a trade-mark in the U. S. Patent Office.

$3.50 a Year *Prices of back numbers on application* ***35c. the Copy***


ALHIER EIN BÜRGER THIELE RÖMER GENANNT
SEINE HAUS FRAU ANNA BREYERS WOHL BEKANNT
ALS MANN ZÆHLTE 1600 IAHR
DEN 9TEN IANUARIUS DES MORGENS 3UHR WAR
VON IHR ZWEY KNABELEIN UND FUNF MÆDELEIN
AUF EINE ZEIT GEBOHREN SEYN
HABEN AUCH DIE HEILIGEN TAUF ERWORBEN
FOLGENDS DEN 20TEN 12 UHR SEELIG GESTORBEN
GOTT WOLLE IHN GEBEN DIE SÆLLIGKEIT
DIE ALLEN GLÆUBIGEN IST BEREIT
OBIGES ORIGINAL=DENKMAL HAT DURCH DIE GÜTE
DES HERRN BÜRGERMEISTER DOMEIER DER IETZIGE
BESITZER DIESES DAMAHLS RÖMERSCHEN HAUSES
GERICHTS SCHREIBER HOPPE, WIEDER ERHALTEN
UND AUFGESTELLET IM IAHRE 1818

THE LIMIT OF HUMAN FECUNDITY?

Frontispiece

Since Aristotle's story of the Egyptian lady who had four sets of quintuplets there has been no lack of fertility in imagination with regard to the maximum number of children which may be born at one time. This German monument to commemorate the birth of septuplets on January 9, 1600, is the most authentic record of such an event that is to be found in the literature. A recent alleged case widely reported in the press appears to be pure fabrication. See "Septuplets with Different Birthdays," page 193.

A DAIRY SIRE PROGENY TEST

B. L. Warwick and O. C. Copeland
Texas Agricultural Experiment Station

MANY papers have appeared in recent years advocating the testing of dairy sires on the basis of the production of their daughters. It is customary to consider a bull as proved when he has five or more tested daughters out of cows which are either a random sample of the breed or are high producers.[9] The results are averaged, and may be compared with the averages of their dams or brought together with various mathematical refinements to be expressed as a single figure or index. As these different procedures have been thoroughly reviewed recently by several authors[1,9,12], they will not be discussed further in this paper. Any one of these procedures is much more to be desired than the selection of bulls on type and pedigree only. Many cull bulls will be quickly discovered and eliminated, and a few bulls highly prepotent for high production may be recognized early enough to allow of far more extensive use. However, it is the purpose of this paper to show that the above procedures are not adequate for *critical* testing and to present, on theoretical grounds, a genetically sound procedure for testing bulls. Suggestions are presented as to a possible means of putting this test into use.

Inheritance of Butter-Fat Yield

The exact mode of inheritance of butter-fat production is not known. However, it is reasonably certain that it is due to a number of factors which are probably of a multiple-factor nature, with a probability of some dominance on the side of high production[4,7,9,12]. While there is a difference of opinion as to whether there is dominance,—and the evidence is conflicting,—the occurrence of apparently highly "prepotent" bulls on rare occasions points strongly toward some dominance. Goodale[2] has recently questioned the validity of the general hypothesis of multiple factors without dominance as accounting for quantitative inheritance. Smith and Robison[12] have presented evidence purporting to point toward sex linkage of part of the dominant factors. In the discussion to follow, ordinary multiple-factor quantitative inheritance, without dominance, will be used as the working basis. However, the conclusions will be even more pertinent if some or all of the factors have more or less dominance.

Use of Test Dams Having Multiple Recessive Factors

Let us assume for simplicity that a herd has been bred up by the slow process of selection to a point where all but five of the many pairs of factors are homozygous. Let us assign an increment value of 1 to each of these five factors, A, B, etc. This increment is to be added to a basic residual production level. We may assume that the population is fairly stable with a high proportion heterozygous for all five pairs. These would each have a value of 5, which we will consider as "good" production. Animals with values of 0 to 4 are "poor" to "medium" producers, See Table I.

If a random sample is taken, it should average about like a group heterozygous for all five pairs. Now, let us examine the evidence as to what the results would be if we used these "good" producers as dams of the test daughters. For comparison, let us include a second group of "poor" producers, each with a known in-

crement value of 0, and a third group theoretically homozygous for all the high factors. Table I gives the comparison of the three types of matings for bulls homozygous for 0 to 5 pairs of factors. It is evident first that if it were possible to have all homozygous high-producing test cows to use, the extent of the range of variation would be the same for their daughters as for daughters of the low producers, and, in the absence of dominance, the homozygous high cows would be as good for testers as the homozygous low ones. Such a group of high-producing homozygous test cows is, however, non-existent. Furthermore, if such a group of homozygous high producers were available, there would be little if any need of sire tests. Accordingly, this kind of test cows will not be discussed further. We see that the progeny of heterozygous test cows are distributed over half the range even when the bull is homozygous for all five pairs. The variability ranges from this to the full length of the scale for animals heterozygous for all five pairs. On the other hand, the maximum variability of the daughters of "poor" test cows is no greater than the least noted above. In either case there are three essential points of information, each of which should be used in evaluating the bull. First in importance is the value of the lowest-producing daughter. This indicates that that particular sire has a genotype carrying enough factors of the undesirable kind to make it possible for him to sire such a poor animal. Next we will consider the average of his daughters. Each kind of test dam gives comparable results except that many more progeny are needed from the "good" test dams. The last is the maximum production. Theoretically, we should be able to get maximum production of 10 from any one of the bulls if heterozygous test cows are used. The value of 5 would be the maximum for each bull when "poor" test cows are used. The important difference here is that with any numbers even remotely feasible the occurrence of the maximum in the sample is only highly probable with bulls homozygous for all or nearly all of the pairs.

These figures are based upon the assumption that the "good" test cows are heterozygous for all five pairs. Similar results would be obtained if some of the "high" factors were homozygous and also enough "low" factors to give the same value of 5. Accordingly, only the one illustration will be presented. It is also recognized that there may be complementary relationships of some of the factors which would materially change the theoretical example given. However, if such assumption is made, it lends argument to the use of test dams having multiple homozygous recessive factors.

Number of Progeny Required

A study of the figures shows that such a small number as 5 or even 15 to 20 is entirely inadequate to pick out either the extremely good or the extremely bad sire when "good" test cows are used. The rather high correlation which has been shown[8] to exist between 6 and 15-20 shows only that the smaller number is nearly as good as the higher, but does not give any evidence as to whether the higher number is large enough for a critical test. Even when the "poor" test cows are used, 15 to 20 daughters would be inadequate for a "critical" test. In the theoretical example given the minimum population to get all progeny classes possible is 32 with the use of low-producing dams, and 1,024 with the use of good-producing dams. In order to have a large enough progeny list to be certain (i. e., 99 out of 100 chances) that the extremes would not be missed by chance, even though genetically possible, the numbers rise to 146 with the use of low-producing and 4,603 with the use of good-producing dams. Obviously such numbers will not be

economically feasible under any ordinary conditions. However, in either case many poor sires can be uncovered and eliminated by paying attention to their poorest daughters, even from small groups. The efficiency is approximately 32 times greater in this theoretical example with the use of the poor producers than with the use of the good producers as the dams. When female testers having multiple homozygous recessive factors are used, each added pair of factors involved doubles the number of progeny needed to get the minimum distribution, but this number must be squared to get the same results if multiple heterozygotes are used instead.

We suggest the use of low-producing dams for the testing of well-bred bulls. Judgment should be based on (1) minimum, (2) average, and (3) maximum production of daughters. The minimum and maximum should be considered as such, rather than only as they affect the coefficient of variation, or other statistical figure.

A bull tested on the above plan would be considered excellent if his daughters included none much below "average," and whose average hovered close to the mid-point between their dams' average production and the maximum of the breed. We would consider such a test with 20 to 25 daughters as of much more moment than that of a bull bred to "good" producers and having 25 daughters averaging somewhat more than their dams, including several below their dams, even if a record producer were included in the list. Even 25 daughters is far from enough to actually prove a sire homozygous. Regardless of the number of tested daughters both the best and the "counterfeit" bulls will be uncovered more surely by using this procedure than by breeding to average or high producers.

Discussion of Previous Suggestions

The possibility of using this type of test animal has been passingly mentioned by Graves,[5] Goodale[2,3] and Jull.[6] However, Graves emphasized it only in relation to publishing the records of *all* the daughters of a bull. After having made a strong point he weakened it by stating that: "In the present stage of our breeding operations, when most cows are probably heterozygous for their inheritance governing producing capacity, a bull's hereditary makeup should probably not be estimated from the producing capacity of less than six daughters." Discussing quantitative inheritance in general, Goodale[2] stated: "As it will not be possible in most cases to use the convenient method of determining the genetic constitution of individuals under test by mating each to multiple homo-

TABLE I.—Progeny distribution in test matings of sires to homozygous high (value = 10), heterozygous (value = 5) and homozygous low dams (value = 0). The table shows the maximum range of variability expected in the daughters of each mating and in the lower line, the minimum number of daughters theoretically necessary to get all possible classes in the progeny. (The number necessary to give reasonable hope of getting all the classes is of course very much larger.)

Values	Sire I AABBCCDDEE			Sire II AaBBCCDDEE			Sire III AaBbCCDDEE			Sire IV AaBbCcDdEE			Sire V AaBbCcDdEe			Sire VI AaBbCcDdEe		
	Dams*			Dams			Dams			Dams			Dams			Dams		
	High	Good	Low	High	Good	Low	High	Good	Low	High	Good	Low	High	Good	Low	High	Good	Low
10	all	1		1	1		1	1		1	1		1	1		1	1	
9		5		1	6		2	7		3	8		4	9		5	10	
8		10			15		1	21		3	28		6	36		10	45	
7		10			20			35		1	56		4	84		10	120	
6		5			15			35			70		1	126		5	210	
5		1	all		6	1		21	1		56	1		126	1	1	252	1
4					1	1		7	2		28	3		84	4		210	5
3								1	1		8	3		36	6		120	10
2											1	1		9	4		45	10
1														1	1		10	5
0																	1	1
		32		2	64	2	4	126	4	8	256	8	16	512	16	32	1024	32

* High = AABBCCDDEE, Good = AaBbCcDdEe, Low = aabbccddee.

zygous recessives, it is necessary to adopt the plan of mating each individual to a variety of other individuals in number sufficient to thoroughly explore its possibilities." While it would theoretically be possible to test a sire adequately by mating to a variety of other individuals, the number of progeny needed would be many times greater than when mated only to animals having multiple homozygous recessive factors.

In a more recent paper on sire tests with particular reference to dairy sires, Goodale[8] discussed briefly the same type of test and considered it the most direct means of evaluating the breeding potentialities of the individual, but did not consider it practical. He stated: "Perhaps some day it may be possible to apply it in the improvement of farm animals but at present there are so many difficulties in the way of its adoption that other means must be substituted." *We are of the opinion that no substitute will ever adequately serve the same purpose.* We question the completeness of the test as it is ordinarily used with good producing dams and with small numbers to thoroughly prove a sire.

Discussing the problem as applied to egg production in poultry, Jull[6] stated: "A proper appraisal of the breeding potentialties of each sire would be possible if he could be mated to dams having the same genes for egg production in a recessive condition." However, he used only high-producing hens for his tester dams in testing sires. We would suggest that the use of low-producing females as tester dams might well be thoroughly tried out with poultry as well as with dairy cattle.

Wilson[13] suggested that the record of the lowest-producing daughter be used as the indication of the bull's worth. He was considering only two pairs of factors to cover all the production.

It might be assumed that any purebred bull would increase the production of all of the daughters over that of low-producing dams. Unfortunately, this is not true, as is well known to the commercial dairyman. Also, the Iowa[7,10] and South Dakota[11] experiments give concrete evidence on this point. Breeding of purebred dairy bulls to low-producing scrub cows at the Iowa Station and beef cows at the South Dakota Station, showed that the daughters of certain bulls produced no more butter-fat than did their low-producing dams. Other bulls used were highly "prepotent." The poor bulls might have been "proved" undesirable by any of the other procedures, but breeding them to low producers showed up their lack of worth more quickly and surely. There should be purebred herds so highly purified in their hereditary makeup that the commercial dairyman could select any bull calf from these herds and be *certain that every daughter would be a profitable producer, even from scrub cows.*

Feasibility of Test

It should be possible to maintain a test herd at relatively low cost. Low-producing "boarder" cows from herds of the same breed might be used. As soon as the low-producing capacity of a cow under good nutritive conditions has once been established, it will be unnecessary to go to further expense of detailed records of her production. Such cows may be run as a "beef herd" mostly on pasture, with a minimum of expense. When a group of such "tester" cows is brought together, they may be pasture-bred to the young bull if conditions are favorable. When the calves are dropped the bull calves may be disposed of either when dropped or as young veal at the earliest feasible age. The dams of these bull calves may then be dried off and re-bred. The heifer calves may be allowed to nurse their mothers while on pasture, thereby eliminating much of the labor incident to calf-raising. When the heifers come

into their first lactation they should be well fed and milked for the first lactation. This initial record will show rather definitely whether the heifer has the ability to respond. If she does not make a creditable showing in this time, it may be considered that it will usually be impossible for her to make even a fair record in succeeding lactations. Individuals which respond fairly well should be profitable producers. The poorest producers may be either sold for beef after the first lactation or thrown into the group of "testers." By resorting to the above scheme of management it should be possible to place the testing of bulls on a relatively low-cost basis. Certainly as long as there are "counterfeit" bulls in our best bovine families, it is almost disastrous to test them by breeding to our best cows and then find that much damage has been done. The more or less common practice of "farming-out" bulls is one scheme to avoid the damage which may result from the unwanted kind of bull. However, this is simply shifting part of the risk to small farmers who should not be expected to shoulder it. We believe that the testing of bulls by some such scheme as the one outlined above will be cheaper, in the end, than those in use today. It seems to us that it is just as pertinent to use this type of test animal as it is to use similar types of testers for qualitative analysis of inheritance, as has been done so effectively with Drosophila. We are advocating this test only as a tool to be used by institutions and private breeders who may be in position to make a real contribution to the dairy breeds.

Summary and Conclusions

1. Any of the progeny tests are better than selection on type and pedigree only.

2. Progeny tests using either a random sample of dams or high-producing dams, require many times as many progeny to give the same information as do tests using poor producers as dams.

3. The use of "cull" producer cows as testers is feasible and a practical plan is presented for putting it into effect.

Literature Cited

1. Edwards, J., 1932. The progeny test as a method of evaluating the dairy sire. *Jour. Agric. Sci.* 22:811-837.

2. Goodale, H. D., 1932. Dominant vs. non-dominant genes in the multiple factor hypothesis of size inheritance. *Jour. Heredity.* 23:487-497.

3. Goodale, H. D., 1933. The progeny test as a means of evaluating the breeding potentialities of farm animals. *American Naturalist.* 67:481-499.

4. Gowen, J. W., 1927. Milk secretion as influenced by inheritance. *Quarterly Review of Biology.* 2:516-531.

5. Graves, R. R., 1925. Improving dairy cattle by the continuous use of the proved dairy sire. *Jour. Dairy Science.* 8:391-404.

6. Jull, M. A., 1933. Progeny testing in poultry breeding as a means of evaluating the breeding potentiality of an individual. *American Naturalist.* 67:500-514.

7. Kildee, H. H. and A. C. McCandlish, 1916. Influence of environment and breeding in increasing dairy production. *Iowa Agr. Exp. Sta. Bul.* 165.

8. Lush, J. L., 1931. The number of daughters necessary to prove a sire. *Jour. Dairy Science.* 14:209-220.

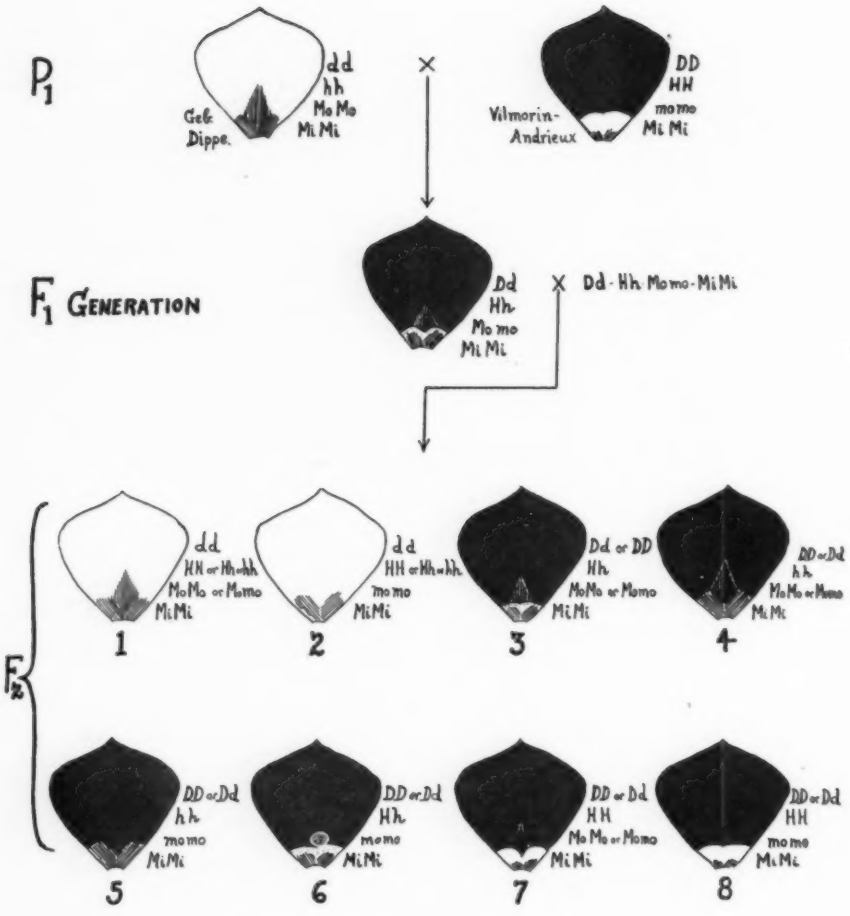
9. Lush, J. L., 1933. The bull index problem in the light of modern genetics. *Jour. Dairy Science.* 16:501-522.

10. McCandlish, A. C., L. S. Gillette, and H. H. Kildee, 1919. Influence of environment and breeding in increasing dairy production II. *Iowa Agr. Exp. Sta. Bul.* 188.

11. Olson, T. M. and G. C. Biggar, 1922. Influence of purebred dairy sires. *S. Dak. Expt. Sta. Bul.* 198.

12. Smith, A. D. B. and O. J. Robison, 1933. The genetics of cattle. *Bibliographia Genetica.* 10:1-104.

13. Wilson J., 1925. A theory of the mode of inheritance of milk yield in cattle. *Jour. Dept. Lands and Agric.* Ireland. 25:1-10. (Original not seen.)



FLOWER TYPE IN A PHLOX CROSS

Figure 1

Diagram showing in row marked P_1 the two parental types; in the second row the general floral type of the first hybrid generation from these two parents; and in the third and fourth rows the floral patterns of the second hybrid generation. Each floral type is represented by a single corolla lobe or petal. To the right of each petal is given the genotypic formula appropriate to each type. Genetic analysis of the various F_2 types confirmed the gene-interpretations here diagrammed.

THE "EYE" OF PHLOX

J. P. KELLY
*Pennsylvania State College**

A COMBINED TYPE

Figure 2

Old commercial type of *Phlox Drummondii* resembling type 7 of this experiment. The star-eye of one grandparent was combined with the halo-eye and colored blade of the other grandparent.

IN an article published in 1920† relating to floral matters in the common annual, *Phlox Drummondii*, the nature of the dark central area of the corolla known as the "eye" was left insufficiently analyzed. Data then available led to the simplest of genetical interpretations, that is, that a single pair of genes. *MM* or *Mm* conditioned the dark-centered, and *mm* the white-centered flower.

Material for further study of flower eyes was found on the farms of certain famous European firms in the summer of 1928. It is a pleasure to acknowledge the generosity of the Vilmorin-Andrieux Company of Paris and Verrières and of Gebrűder Dippe of Quedlinburg. Doctor Kappert, geneticist for the latter house, forwarded the ripened seed of marked plants of *Phlox Drummondii* whose flowers had white blades combined with a striking, star-shaped eye of a deep violet (diagrammed in Figure 1, top row, left). Doctor Meunissier, plant breeder for the Vilmorin-Andrieux Company, harvested seed of selected plants whose flowers had deep violet blades associated with a halo-type of white eye (diagrammed in Figure 1, top row, right). These German and French stocks were crossed, and their descendants observed

*Publication authorized by the Director of the Pennsylvania Agricultural Experiment Station December 4, 1933, as Technical Paper No. 622. This is contribution No. 93 of the Botany Department of the Pennsylvania State College.

†KELLY, J. P. A genetical study of flower form and flower color in *Phlox Drummondii*. *Genetics* V: 189-248.—1920.

TWO TYPES OF STAR-EYE

Figure 3

Right, star-eyed, white-bladed plant like the original parental type used. Left, a star-eyed type appearing in F_2 and F_3 generations with outer part of the star isolated and weakened presumably from having acquired the gene for halo-eye (*H-H*) in the course of the reassortments involved in this experiment.

through three generations, affording the basis for the fuller treatment of eye inheritance contained in this paper.

The first (F_1) generation after crossing was represented by two families. One had a dozen sibs uniform among themselves for flower color and pattern. The second family contained ten plants, one just like any other in their group. The two families differed in one feature: all in the first had the blade pigment lightening toward the edge while all in the second family had the blade pigment equally intense all over. The F_1 condition represented in Figure 1 shows the uniform-bladed type. Different star-eyed plants had been used as P_1 parents and a dormant dominant gene affecting blade color distribution was evidently introduced through one.

The F_1 plants all showed hyacinth-violet pigment in the blade or outer part of the corolla, i. e., the white of the star-eyed parents is completely recessive. As regards the central region, the star-eye of one parent was struggling for expression with the halo-eye of the other parent in all twenty-two of the F_1 hybrids. The center of the flower, in other words, was intermediate between the two parents. The halo was often found lightly colored or muddy-looking and lessened in size. The paired radial bars next the flower throat, making the center of a star eye, tended to be intermediate in size (see Figure 1 again) as a result of the presence of the gene for halo in heterozygous condition. The shortening of these bars was accompanied by the isolation and lightening of the outer part of the star eye. The F_1 star, in other words, appeared broken up and less conspicuous.

Eighteen of the F_1 plants were self-pollinated to give seed for an F_2 group of 429 plants. The flowers of the F_2 generation were in general of eight kinds. The types were not always determinable on inspection, for F_3 descendants of various F_2 plants showed some misclassification. Referring again to Figure 1, we find the eight F_2 types represented by diagrams of a single corolla lobe of each floral type.

Examining the F_2 generation, we see that in type No. 1 we have retrieved the Gebrűder Dippe star-eyed white-bladed grandparent. There was not absolute uniformity among the plants classified as No. 1. There were

some whose star was somewhat broken, that is, in which the outer points or color flashes of the star eye were separated a bit from the ten throat bars (see Figure 3, left). Such a condition was considered due to the factor for halo eye being present. Where the star was solid (Figure 3, right) the halo gene was thought absent. In No. 8 we find a segregation out of the Vilmorin-Andrieux halo-eyed violet-bladed grandparent.

No. 3 repeats the characters of the F_1 flowers.

No. 2 is interesting as a demonstration that the original star-eye is not a simple hereditary trait. The dark center of No. 2 is really just the central feature of the original star eye, i. e., the throat bars or striae. No. 2 has, therefore, a ring-shaped dark area due to the loss of the set of five central blade flashes that made the points of the original star-eye. The eye bars of type 2 are short on some plants and vary presumably because of the presence or absence of the halo character whose effects are not otherwise detectable.

Type 4 shows the recombination of certain features of both grandparents into a distinctive plant. The violet blade of one is put together with the complete star-eye of the other grandparent. No halo is present to weaken or break up the pigment mass at the center. The appearance of No. 4 recreates a type mentioned in *Genetics* heretofore (Vol. VI, p. 211).

Type 5 of the F_2 generation is in all respects like No. 4 but the eye is thought merely the set of throat bars of the star and not the whole star. It was difficult to distinguish 5 from 4, especially at first, and the tendency was to throw all into 4.

Type 6 is like No. 3 except for the absence of the outer flash of color. Eye or center is merely the set of throat bars.

Type 7 is another recombination of certain ancestral features: the outer part of the star-eye of the original star-eyed grandparent combined with the halo-eye and colored blade of the other grandparent. No. 7 is considered as possessing the hereditary possibilities for complete star-eye. The star is retracted in its expression and its outer parts obviously disjoined from its throat parts, presumably by homozygous halo-eye. (See Figure 2 for photograph of an old commercial variety that exhibits this pattern.)

The pertinent genes behind the scenes responsible for the diversities of the F_2 generation are inserted in Figure 1. In place of the gene *M* used in the article in *Genetics* for March, 1920, we set up a pair of independent genes for the large star-center. For the star eye of the German grandparent the gene *Mi* leads to the formation of the inner part of the star-eye, the set of throat bars; and gene *Mo* brings in the color making the outer part of the star eye. The French grandparent contained *Mi* and the recessive *mo*; the French ring-eye was reduced by the gene *H* for white-eye; the gene *H* interacts apparently with *Mi* and restricts its expression. The factor *D* (used in *Genetics* VI: p. 218) is present in the halo-eyed grandparent underlying the blade color development.

For the F_1 generation, therefore, the genotype is *D-d+Mo-mo+H-h+Mi-Mi* for the floral features in which we are interested.

With no linkage one would expect as the F_2 generation (for a group of 429 plants) roughly: 81 No. 1; 27 No. 2; 120 No. 3; 60 No. 4; 20 No. 5; 40 No. 6; 60 No. 7; 20 No. 8.

The actual numbers differed considerably: 70 No. 1; 32 No. 2; 126 No. 3; 111 No. 4; 10 No. 5; 17 No. 6; 33 No. 7; 26 No. 8; along with four plants whose colors were reduced to a mere tinting, making it impossible to classify them.

The deviation of the experimental numbers is not to be attributed to linkage nor to the play of chance but to difficulties of grouping on the part

of the observer. F_3 families raised to check the grouping of the F_2 showed there was a bias (to the extent of 7% about) on the part of the recorder toward making fours out of threes in the F_2. Again, in the case of 24 apparent threes in the F_2 represented by F_3 descendants, five were really of type 6. Only two of type 6 gave F_3 progeny—an inadequate test. In actual experimentation the flower patterns were not always as sharply marked off as Figure 1 might suggest. Even among the flowers on one plant considerable fluctuation was often present and the deviations of the experimental numbers from the theoretic might be due to circumstances of this sort.

However, *on the whole*, the 92 families comprised in the F_3 generation corroborated the gene interpretations attempted here and entered in detail in Figure 1. This means that star-eyed whites of the F_2 tended to yield families all star-eyed white or mixtures of star-eyed and ring-eyed whites. Type 2 plants of the F_2 generation tended to repeat their features in all their progeny. F_2 individuals of type 3 usually gave families that were mixtures of many of the possible eight sorts. F_2 segregates of type 4 gave F_3 families all of four or mixtures of four, one, two (five was also to be expected here but it was not recorded). Where F_3 decendants have been secured from other F_2 plants they also pointed toward the validity of the gene framework here set up.

Pediatrics and Genetics

TRAITÉ DE MÉDÉCINE DES ENFANTS, published under the direction of P. Nobécourt and L. Babonneix, Tome I. Pp. 884; about 300 illustrations and graphs. Masson et Cie., Paris, 1934.

THE preface informs us that this is the first comprehensive treatise on pediatric medicine to appear in French since 1909. It is a collaborative work, in five octavo volumes, with contributions by more than seventy specialists. The chief sections in the present volume are devoted to growth and growth anomalies, nutritional diseases, endocrine disorders, and aberrations in temperature regulation.

Heredity is mentioned as a possible etiological factor in about a dozen of the conditions discussed, receiving most attention (a full page, with 11 literature references) in the section on diabetes mellitus. In general, what treatment there is of genetic topics is brief, uncritical, and archaic. It is encouraging to find, however, that a chapter entitled "Affections Congenitales," by E. Apert, is largely devoted to an exposition of elementary genetic principles. This chapter includes a rather sketchy presentation, not always lucid nor altogether flawless, of simple mendelism and sex-linked inheritance, with some indication of of the wider possibilities of the subject; a number of hereditary malformations are figured and described. Apert, who, it incidentally appears, was one of the first to apply mendelian interpretation to human pathological heredity, points out the peculiar difficulties of human material for genetic analysis, but makes no mention of the special methods which are being developed to deal with human genetics.

Whether or not more attention to genetic matters is to be expected in a work of this kind, the reviewer does not know. Certainly, the contributions which genetics has to make to medical practice in general have been sufficiently stressed by authors in this JOURNAL, and elsewhere by Hogben, Snyder, and others, to require no iteration here, and it would be gratifying to find more attention given to them in medical works.

PAUL R. DAVID
Storrs Agricultural Experiment Station

TASTE BLINDNESS AND RACE

LELAND W. PARR*

Department of Bacteriology, Hygiene and Preventive Medicine, School of Medicine, George Washington University, Washington, D. C.

DIFFERENT sensory thresholds undoubtedly exist in different individuals for the same given stimulus. In some instances the threshold may be so high that its possessor may to all intents and purposes be considered "blind" to the stimulus. If it can be shown that such sense-differences are definitely inherited characters whose incidence varies in different races, a basis exists for the use of such tests to determine racial affinities of the peoples of the world.

The = C = S linkage group in certain synthetic compounds closely related to dulcin, such as para-ethoxy-phenyl-thio-carbamide and phenyl-thio-carbamide, is a stimulus which reveals taste differences which are hereditary. Di-ortho-tolyl-thio-carbamide possesses somewhat similar properties. Attention was first called to Fox's work with this group of chemicals by *Science*[9] which briefly reported his findings. Fox discovered that such chemicals were tasted as intensely bitter by some and not tasted at all by others. Blakeslee and Fox reported to the readers of this JOURNAL[5] the early history of this discovery and its interesting genetic implications. In that article is also to be found a discussion of the chemical structure of the carbamides, and of related substances such as dulcin and saccharine.

The carbamides are not the only substances capable of eliciting different grades of taste response from different persons. Biester, Wood, and Wahlin[1] reported differences for sugars; Munch[12] for capsicum; and Ward and Munch[18] for strychnine. Furthermore, Blakeslee and Fox note that taste response differences exist for fumar protocetraric acid, a constituent of lichens; for cetrarin or cetraric acid; and for benzoate of soda.

Odor or fragrance perception is so closely related to taste perception that one may well mention that Blakeslee[2] and Blakeslee and Fox have reported that "odor blindness" likewise exists, notably toward such stimuli as certain verbenas, freesias, wild apple blossoms, crab apple blossoms, yellow day lilies, and azaleas. V. du Vigneaud[7] has suggested that individual differences exist as regards perception of hydrocyanic acid gas.

There is thus much evidence that different people live in different worlds as far as reactions to sensory stimulations are concerned. Further researches along these lines will undoubtedly bring to light many new substances toward which a certain proportion of our population is "sense blind." In some instances, hydrocyanic gas, for example, information regarding such differences might have considerable practical value.

The boundary, however, between ability to taste the pure dry crystals, or a .5% "P-T-C" solution and the ability to taste only a warm saturated solution appears to have a distinct significance and divides subjects into bitter tasters and those who, being negative reactors, may be spoken of as taste deficient or taste blind. That this distinction is justified will be evi-

*The data here reported were presented as part of a paper entitled "Physiological Approaches to the Study of Anthropology with Special Reference to the Near East," which was read June 23, 1933, at Chicago, Illinois, before Section H of the American Association for the Advancement of Science and Allied Societies, 92nd Annual Meeting.

dent from a study of the genetic findings on taste reaction to phenyl-thio-carbamide reported by Blakeslee and Salmon[6] and by Snyder[17] from which it is evident that taste blindness to this chemical is innate and inherited as a Mendelian recessive. From our own observations it seems probable that this hereditary character is not associated in close linkage with the characters which determine the blood groups.*

Taste acuity for phenyl-thio-carbamide has no close relationship to taste acuity for such other bitter compounds as picric acid and quinine sulphate, nor does it appear to be affected by such factors as age, sex, state of health, time of day, recency of taking food, salivary pH, gum chewing, use of tobacco, mouth rinses, false teeth, or other factors which might occur to one as affecting taste perception. It should be added that, curiously, among those who fail to taste the thio-carbamides as bitter are some who taste them as sweet, salt, or sour.

Racial Differences

The first application of the Fox test to racial study was the work of Levine and Anderson[11] testing 183 pure North American Indians at the Haskell Institute, Lawrence, Kansas. They reported that 93.9% were bitter tasters. This figure is much higher than the commonly accepted value for American whites. Quite significant is the fact that 110 Indians with some white admixture tested by Levine and Anderson were only 87% bitter tasters. In other work on races, utilizing inherited characteristics, where two pure races and hybrids thereof have been tested the results for the cross tend to fall between those for the two pure races crossed. This has been demonstrated in blood typing studies for negroes and whites by Lewis and Henderson [10], for Indians and Whites by Snyder[15], and for Jamaicans and whites by Snyder.

In 1932, sensing a possible application of the Fox test to racial† study, we distributed a supply of "P-T-C" paper‡ and full directions for its use to a number of former associates and friends whose ability to carry out experimental work could be vouched for, and they were invited to participate in a proposed survey of taste blindness in different racial groups. We wish here to express appreciation for the prompt and thorough response of the following collaborators:

Dr. W. W. Hickman and Labib Effendi Morcos, Assiut College, Assiut, Egypt.
Dr. Ellis H. Hudson and Clara N. Peter, R. N., Deir-es-Zore, Syria.
Dr. Dikran Berberian, American University, Beirut, Syria.
Dr. Rina Yunovitch, Hadassah Hospital, Tel Aviv, Palestine.
Miss Cora Howard, Andalusia, Alabama.
Mrs. M. M. Campbell, Americus, Georgia.
Mr. S. F. Chen, Washington, D. C.
Mr. S. C. Chain, New York, N. Y.

The test is a relatively simple one, consisting merely in the determination of the taste reaction of the subject to phenyl - thio - carbamide paper. Like many other simple tests, however, especially where the human element is involved, it has its pitfalls. One of these pitfalls, i. e., knowledge of what is bitter, was controlled by asking for

*It was this possibility of linkage of taste deficiency with blood groups which led the author into this field of physiology and genetics.

†The term "race" as used in this paper is understood not to be in strict accord with a proper anthropological understanding of its meaning.

‡The phenyl-thio-carbamide test paper used in our work was furnished us by Mr. Robert C. Cook, Editor of the JOURNAL OF HEREDITY, who prepared it by soaking paper in a .5 per cent acetone solution of the crystals, and eliminating the solvent by evaporation. This method has been found to have certain advantages, other than that of economy, over the use of crystals in capsules which were utilized in the New Orleans Taste Exhibit Tests. A .5 per cent concentration is by this means presented to the subject on paper, a piece of which he chews until he is able definitely to name the taste reaction obtained or to be sure no taste at all is perceived. It should be stated for the benefit of those who may have seen and used the samples of "P-T-C" paper distributed in one of the numbers of the JOURNAL OF HEREDITY that the paper used in our test was of somewhat different texture and preparation from that distributed in the JOURNAL and in our opinion more thoroughly and uniformly impregnated with the chemical.

the name of a substance known to the subject having the same taste to him as the test paper. Our staff was cautioned to rule out so far as possible the element of suggestion by testing their subjects individually and not *en masse*. As far as possible any reference to the taste to be expected has been avoided in advance of making the test.

It has been objected to this test that there are subjects who do not know the meaning of bitter. This objection would be particularly pertinent in our work where in many of the cases the subjects tested have an imperfect knowledge of English. In all our work, therefore, we have insisted that the subject state what substance in his previous tasting experience is similar to the "P-T-C" paper in taste. Furthermore all groups worked with have been handled by workers who are fully acquainted with the language, foods and medicines, and the psychology of the subjects tested.

In Table I* we present our findings and include for comparison Levine and Anderson's data on Indians and Snyder's figures for American whites.

Discussion

No race group has yet been discovered in which every individual could taste phenyl-thio-carbamide as bitter. The high percentage of tasters observed among the Chinese and the pure American Indians indicates that it is not unlikely that such a race group exists. The results thus far obtained indicate there is less likelihood of finding a group entirely taste blind. Is this failure to taste an advance in evolution or an atavistic throwback? What, if anything, is its function? Medical science has long been in search of accurate indicators of constitution and of disease resistance and susceptibility which can be detected with a comparatively simple technique. In this connection the blood groups have been rather thoroughly tested and, for this purpose, found disappointing. May we expect as little from this innate inherited characteristic of thio-carbamide tasting? These and other questions had best be left until more work has been done on this problem.

All that can be said on the basis of the present study is that similar racial percentages of taste blindness, such as occur among the Egyptians and the American negroes do not imply more than a similar possession of taster capacity by these races. We are interested, ourselves, in the fact that the percentage of tasters among Arabic speaking Egyptians differs from that among the Arabic speaking Syrians for from our blood typing studies[13] we have demonstrated considerable difference between Syrians and Egyptians. Racial taster figures are suggestive additions to other avenues of study available to the anthropologist but in themselves should not determine racial identity or dissimilarity. On the other hand, leads given by such means should receive attention and suggest-

*TABLE I.—Results of Taste Blindness Tests made on Different Race Groups

Group	Worker	Place	Total number tested	% of bitter tasters
Chinese	Chen & Chain	Washington-New York	167	94.01
Pure American Indians	Levine & Anderson	Kansas	183	93.9
Mixed American Indians	Levine & Anderson	Kansas	110	87.2
Negroes	Howard & Campbell	Alabama-Georgia	533	76.5
Egyptians	Hickman & Morcos	Egypt	208	75.9
Sephardim or Southern Jews	Yunovitch	Palestine	175	72.0
American Whites	Snyder	Ohio State Univ.	3,643	70.2
American Whites	Parr	Washington	439	69.1
Aschkenasim or Northern Jews	Yunovitch	Palestine	245	68.5
Armenians	Berberian	Syria	294	68.02
Semenites	Yunovitch	Palestine	59	67.7
Arabs	Hudson & Peter	Interior Syria	400	63.5

ed similarities and differences deserve the study of the anthropologist. Our feeling regarding this suggestion is strengthened by the findings of Levine and Anderson with pure and mixed Indians and by our findings with Egyptians and Syrians. From the physiological side it would seem that this question which has hitherto been largely handled from the point of view of genetics might well come in for some investigation.

Summary

This paper reports taste blindness tests applied for the first time on a large scale to racial study. Taste blindness is an inherited inability to taste certain thio-carbamides as crystals or in cold diluted solutions as bitter. This blindness or deficiency is a Mendelian recessive. American whites and Indians have previously been tested but in this study are added Chinese, Negroes, Arabs, Jews, Egyptians, Armenians, and a control group of whites. Tests for inherited differences in sense acuity may reasonably be used in the study of races. It is suggested that the phenomenon of taste blindness is worthy of further study, whether from the anthropological or the physiological point of view.

Literature Cited

1. Biester, A., M. W. Wood, and C. S. Wahlin, *Am. J. Physiol.*, 73, 387, 1925.
2. Blakeslee, A. F., *Science*, N. S., 48, 298, 1918.
3. ————, *Science*, 74, 607, 1931.
4. ————, *Proc. Nat. Acad. Sc.*, 18, 120, 1932.
5. Blakeslee, A. F., and A. L. Fox, *Jour. Hered.*, 23, 97, 1932.
6. Blakeslee, A. F., and M. R. Salmon, *Eugenical News*, 16, 105, 1931.
7. du Vigneaud, V., Personal communication, 1932.
8. Fox, A. L., *Proc. Nat. Acad. Sc.*, 18, 115, 1932.
9. "Items" (First note on work of A. L. Fox, April 17) *Science*, 73, 14, 1931.
10. Lewis, J. H., and D. L. Henderson, *J. Am. Med. Assn.*, 79, 1422, 1922.
11. Levine, P., and A. S. Anderson, *Science*, 75, 497, 1932.
12. Munch, J. C., *J. Am. Pharm. Assn.*, 18, 1236, 1929.
13. Parr, L. W., *Am. J. Phys. Anthrop.*, 16, 15, 1931.
14. *Science News Letter*, (April 18, note on work of A. L. Fox), 1931.
15. Snyder, L. H., *Blood Grouping in Relation to Clinical and Legal Medicine.* Williams and Wilkins, Baltimore, 1929.
16. ————, *Science*, 74, 151, 1931.
17. ————, *Ohio J. Sc.*, 32, 436, 1932.
18. Ward, J. C., and J. C. Munch, *J. Am. Pharm. Assn.*, 19, 1057, 1930.

A Mutational Theory of Cancer

THE ORIGIN OF CANCER, *by* J. P. Lockhart-Mummery, M. B., B. C., (Cantab.), F. R. C. S. (Eng.) Senior Surgeon, St. Mark's Hospital; Chairman Executive Committee and Editor of the Annual Report, British Empire Cancer Campaign. Pages, 150, bibliography, and index, 29 illustrations. Price, 10s. 6d. J. & A. Churchill London, 1934.

NOT many years ago the surgeon who showed more than a passing interest in any biological phase of the cancer problem was a rarity. He was somewhat surreptitious in making any such interest manifest because he feared loss of caste and condemnation from his associates.

The change in this attitude has been sudden and extensive. It is therefore entirely within the bounds of reason that a distinguished surgeon has adopted a characteristically biological explanation for the origin of cancer and has presented his ideas on the subject in an attractively prepared and well printed book.

The particular process which Lockhart-Mummery uses to explain the origin of cancer is that of genetic change in a normal growing somatic cell. This process, called by geneticists "somatic mutation," is well known. Lockhart-Mummery quotes the more general articles on the subject but has not mentioned many cases of somatic

(*Continued on page* 197)

HERITABLE CHARACTERS IN MAIZE

XLVIII—Dwarf$_6$

WILLIAM H. EYSTER
Bucknell University

MAIZE dwarf$_6$ was first observed in the progeny of a self fertilized plant of the commercial strain of maize known as Golden Beauty which was grown some years ago on the experimental grounds of the University of Missouri.

Dwarf$_6$ can not be distinguished easily in the seedling stage from its normal sibs. Its leaves, however, do extend upward so as to produce a sharper angle with the stem. It is only when the normal plants outgrow the dwarf$_6$ plants in height that the latter can be recognized definitely. The general appearance of the dwarf$_6$ plants is shown in Figure 4 (left). In the mature plant the lower leaves extend upward at a sharp angle from the stem while the uppermost leaves are rolled about each other and often this terminal roll of leaves completely encloses the tassel. Not infrequently the tassel never emerges and the pollen is not shed.

In Figure 4 (right) is shown a dwarf$_6$ plant in which the terminal roll of leaves has been separated so as to expose the tassel. When this operation is performed the tassel sheds a limited amount of pollen. The nodes immediately below the tassel are extremely short as compared with those in the ear shoot region below.

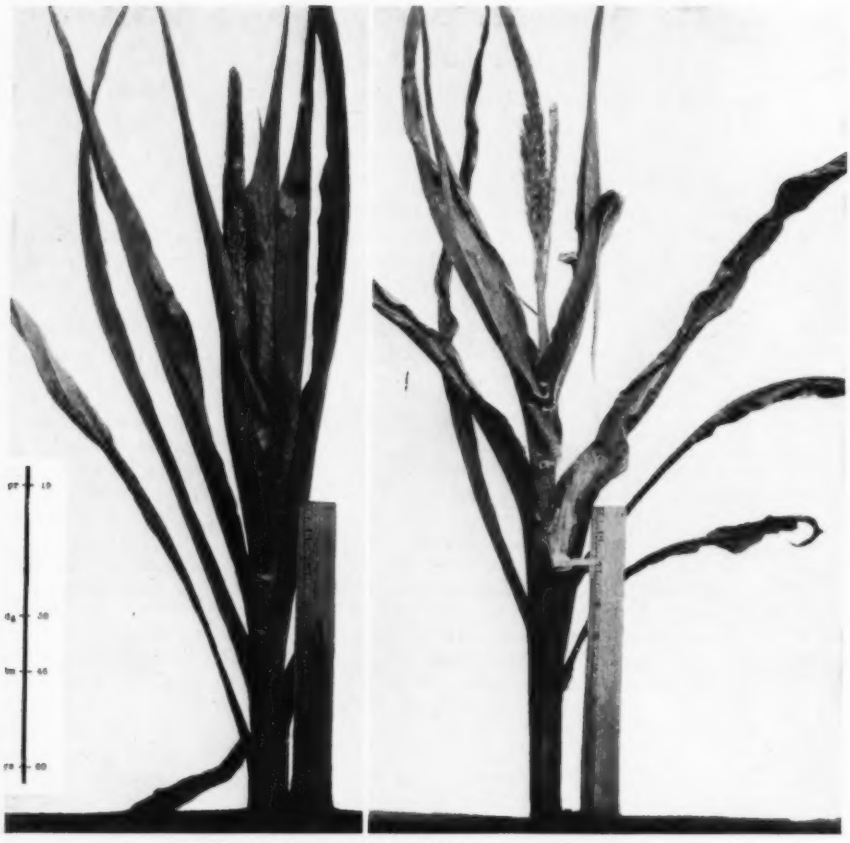
Dwarf$_6$ is inherited as a simple Mendelian character and is recessive to the normal stem. Under field conditions some of the weaker dwarf plants tend to die so that segregating progenies which are noted late in the growing season may show a deficiency of dwarf plants.

Gene on Chromosome 5

The first indication of the linkage group to which the gene for dwarf$_6$, d_6, belongs was given by a progeny which segregated purple and red aleurone and normal and dwarf$_6$ plants. The plants grown from the purple kernels included all of the dwarf plants while the red kernels gave rise to normal plants exclusively. Other progenies which segregated these two pairs of characters have substantiated this linkage relationship. The data which are at present available on this relationship are recorded in section *A* of Table I. These data include seven F_2 progenies in the repulsion phase and indicate a linkage between the genes for purple aleurone and dwarf$_6$ with approximately 20 per cent crossing over. In section *B* of Table I are given data on a single F_2 progeny involving purple aleurone and dwarf$_6$ in the coupling phase. These data show a linkage between the genes of these characters with about 18 per cent crossing over. The average per cent of crossing over, considering the data of the repulsion and coupling series, is approximately

TABLE I.—F_2 Progenies involving Dwarf$_6$ in Maize.

Pedigree		Coupling or Repulsion	g	h	AB	Ab	aB	ab
12270-6 (X)	A	Repulsion	pr	d_6	94	31	33	1
" -7 (X)		"	"	"	30	12	16	0
13322-1 (X)		"	"	"	97	41	80	1
" -9 (X)		"	"	"	36	15	61	1
" -19 (X)		"	"	"	56	22	7	1
" -23 (X)		"	"	"	64	48	64	4
" -66 (X)		"	"	"	64	30	42	1
Totals		"	"	"	425	218	215	10
11255-5 (X)	B	Coupling	"	"	111	7	4	25
13255-6 (X)	C	Repulsion	d_6	bm	147	61	62	0
13322-6 (X)		"	"	"	99	79	84	0
" -1 (X)		"	"	"	163	66	80	1
" -98 (X)		"	"	"	149	55	25	0
Totals		"	"	"	538	212	171	1
12270-6 (X)	D	Repulsion	d_6	ys	172	41	57	1



ANOTHER DWARF FORM OF MAIZE

Figure 4

The plant at the left shows the normal habit of growth of a mature plant of dwarf$_6$. At the right is a similar plant with the terminal leaf roll separated to expose the tassel. The insert at the left shows the preliminary map of chromosome 5 in maize with the genes thus far located in this chromosome. Dwarf$_6$ lies between purple aleurone (*pr*) and brown midrib (*bn*). Beyond the latter lies the gene for yellow stripe (*ys*).

19 per cent. This linkage relationship shows definitely that the locus of d_6 is in chromosome 5 at about 19 cross-over units from that of *pr*.

The linkage relationship of dwarf$_6$ indicated above was further substantiated by tests with brown-midrib the locus of which is known to be in chromosome 5. Four F_2 progenies which segregated dwarf$_6$ and brown-midrib in repulsion phase are recorded in section *C* of Table I. These data show a linkage between the genes for dwarf$_6$ and brown-midrib with slightly more than 8 per cent crossing over.

Extensive data on the linkage relations between the genes for purple aleurone and brown-midrib, to be published elsewhere, show a linkage between these pairs of characters with about 24 per cent crossing over. This relationship as well as those shown to

exist between *pr* and d_6 and between d_6 and *bm* show that the loci of these genes have the order *pr* - d_6 - *bm* as indicated diagrammatically in Figure 4.

The locus of the gene for yellow-stripe, *ys*, was shown by Beadle* to be in chromosome 5. In section *D* of Table I are given data on a single F_2 progeny which segregated dwarf$_6$ and yellow-stripe in the repulsion phase. These results indicate a linkage between d_6 and *ys* with somewhat more than 18 per cent crossing over. An F_2 progeny which segregated yellow-stripe and brown-midrib indicates a linkage between these characters with about 14 per cent crossing over. These relationships indicate that the locus of *ys* is on the opposite side of the locus of *bm* from the loci for d_6 and *pr*. Accordingly, the order of the loci in chromosome 5 mentioned above is *pr* - d_6 - *bm* - *ys*, as shown by the diagram in Figure 4.

"SEPTUPLETS" WITH DIFFERENT BIRTHDAYS

BETWEEN one and two per cent of all births are twins. The proportion of triplets and quadruplets is much smaller. A definite statistical relation seems to obtain between the frequency of these events, the frequency of triplet births being roughly proportional to the square, and of quadruplet births to the cube, of the frequency of twin births. Thus about one birth in seventy-five hundred is a triplet and one in some three-quarters of a million is a quadruplet. The birth of quintuplets is an extremely rare phenomenon, and only a few unquestionably authentic instances of septuplets are to be found in the medical literature.

The percentage of offspring of multiple births which reach maturity is an even smaller proportion of the population. The hazards of birth both for mother and child are increased progressively with increasing numbers, and twins, triplets, and quadruplets have progressively lessened chances of survival. In the United States at the present time only a few sets of quadruplets have reached maturity. We are not aware of any cases of more than four at a birth in which the children have all lived to maturity, though there may be such instances on record.

The upper limit of human fecundity at one birth seems to be rather indefinite. Some months ago this question was brought forcibly to our attention when an account of an alleged case of septuplets was widely circulated in the daily press. Many inquiries regarding this story were received, and in attempting to verify it, we discovered how extremely rare, if not actually mythical, all such cases are. The following quotation from the *Syracuse Post Standard* for October 25, 1933, is typical of a number of such dispatches that reached this office:

WOMAN GIVES BIRTH TO SEVEN SONS AT ONCE

Believed Unique in Medical History

Georgetown, British Guiana, Oct. 24. (AP)—Senora Carola Perez today was caring for seven sons born to her in one delivery. Physicians regarded the septet birth as unique in medical history. The mother and all the children were reported as "doing nicely." The senate of the Bolivar department listened to an appeal for a government grant to the Perez family, whose head is Senor Luis Perez, then referred the matter to the department of public works. Inquiry at the New York Academy of Medicine brought information that there is not in gynecological records a single case "absolutely substantiated" of multiple birth more than six. Even six is an extremely rare event.

Newspaper vital statistics, especially where the source of information is a remote region, are sometimes

*Beadle, G. W. Yellow-stripe—a factor for chlorophyll deficiency in maize located in the *Pr pr* chromosome. *Amer. Nat.* 63: 139-151. 1929.

FIVE DAUGHTERS AT ONE TIME

Figure 5

Mrs. Ovila Dionne and her five daughters, Cecile, Yvonne, Marie, Emily, and Annette. Born May 27 all five of the quintuplets have survived the first two weeks of life thus establishing what appears to be a record in authentic medical annals. Incubator existence and a strict quarantine to prevent infection makes it difficult to obtain much first hand information about the babies. Should they survive and should they prove to be identical, their bringing up under five different environments would, were that possible, be a most illuminating test of the relative importance of nature and nurture.

far from accurate. It seemed, therefore, worth while to attempt to obtain first-hand information regarding this case, and a copy of this dispatch was sent to Dr. Henry Pittier, Director of the Museum National at Caracas, Venezuela. Dr. Pittier, who has long been a member of the A. G. A., generously undertook to verify this report. He was able to obtain first-hand information from Georgetown which completely disposes of this alleged phenomenon. We have only recently heard from him regarding the details of this "journalistic joke" which has been so widely circulated as serious fact. To quote directly from his letter:

> Until a few years ago I did not get any answers to my inquiries about the extraordinary case of a woman giving birth to seven babies. Now they tell me there is a woman named Carola Perez with several children of various ages but all born separately. The story is called a "journalistic joke." Of course, one could have known before hand that such a thing could not be.
>
> I am sorry I did not keep an issue of the local *Espera* of a few days ago, in which one could read such statements as (textually translated): "Our women are noted for their fecundity; parturitions of two, four, six, eight, and even ten children at one time are not infrequent." This gives you an idea of the reliance to be put on the Spanish American press.

Since Senora Perez and her large family of "consecutive septuplets" are definitely out of the running, it may be of interest to refer briefly to such other instances of extreme fecundity as are given varying degrees of authenticity in the literature. Several cases of sextuplets are on record, but Dr. Pittier seems well justified in his view that as far as septuplets are concerned "such a thing could not be." Authentic instances of multiple births of such proportions would be of real interest and possibly some of the readers of the JOURNAL will be able to cite references to better authenticated cases. There are many stories of more populous parturitions, but all of them lack really adequate confirmation. It happened that a few months ago the photograph reproduced as the Frontispiece of this issue, was received by us quite independently of the Perez case. It is interesting to find that Miss Julia Bell, in an extensive search of the literature on this subject, considers this German case is perhaps the most authentic instance of septuplets on record.*

This monument to a birth of seven is located in the town of Hamelin-on-Weser in Germany. Hamelin it will be recalled is famous for the fecundity of its rats, and for its music-loving children, as recounted in the legend of the Pied Piper. Perhaps the Pied Piper myth indicates the presence in this region of a gene for making the most of a good story which might cast a shadow of doubt on the actuality of the septuplets in question. The house bearing this monument is located at 3 Emmernstrasse in Hamelin and the translated inscription reads as follows:

> Here resided a citizen, Roemer by name. His wife, Anna Breyers, well-known in the town, when they counted the year 1600. On January 9, in the morning at three, she bare two boys and five maidens at one time. They having received holy baptism, died a blessed death on the 20th of the same month at twelve o'clock. May God grant them that blessedness which is prepared for all believers.

> The above original monument, through the kindness of the Burgomaster Domeier, has again been received by Hoppe, clerk of the court, the present owner of this house, formerly belonging to the Roemer family, and by him re-erected in the year 1818.

It is clear from the last sentence of the above quotation that the inscribed base is of a later date than the original plaque. Thus in this case, as in all of the other cases of large numbers of children at one birth, the evidence is not without elements of

---

*For a most interesting discussion of this subject see BELL, JULIA, Plural Births with a New Pedigree, *Biometrika*, XX:110-120. May, 1933.

uncertainty. When the plaque was originally placed in position, when and why it was removed, and what happened to the original inscription are points on which we have no information.

A noteworthy and curious feature of this case is that it appears from the inscription that the septuplets all survived from the ninth to the twentieth of January. Almost without exception when more than four are born at one time the children are born dead or survive only a short time. That all of the seven simultaneously gave up the ghost on the eleventh day is a remarkable circumstance. It may perhaps lead the skeptical to suspect that the inscription was not prepared until long enough after the event so that some features had become partly legendary. If this is the case, it casts considerable doubt on the value of this monument as evidence.

The World's Great Mammas and Papas

Miss Bell considers at some length the various other serious (and not so serious) claims of record-breaking multiple births, from Aristotle to the present time. She dismisses as a myth the oft-repeated story of the Grafin Von Hennenberg and her three hundred and sixty-five children at one birth. The relation between the progeny of this titled lady and the number of days in the year strongly suggests that the myth is quite respectable antiquity. She then discusses the cases of the two Margarets, whose claims have come down from medieval times. The Polish Margaret, the wife of Count Verboslaus, "brought forth at one birth thirty-five live children, upon the 20th day of January in the year 1296." The Spanish Margaret, three hundred years later, put her Polish competitor to shame: "The mid-wives and several doctors of Valencia are witnesses, counting the children that her two husbands had the good fortune to have. They found one hundred and forty-four males and forty females. Amongst them there were baptized forty-nine sons and three females." As this account gives a total of thirty-five parturitions in only twenty years, Miss Bell is skeptical about the lady's procreative activity and suspects either a misprint or an inability on the part of the mid-wives and doctors of Valencia to keep an accurate account. A more modern contender is an Italian woman, who in 1886 was reported to have accumulated quite an amazing progeny. At that time she was forty-seven, and "had been married at the age of twenty-eight to a peasant just nineteen years ago. Maddalena Granata has given birth to, either dead or living, fifty-two children, forty-nine of whom were males. . . . She has had triplets fifteen times." That, as Miss Bell remarks, "seems incredible," which is doubtless the case, as attempts at verification were without result.

The all-time record for paternity seems to be held by a Russian peasant, Feodor Wassilief. This gentleman's record, which seems to have considerable official authentication, is as follows:

By his first wife:		
4	× 4	16
7	× 3	21
16	× 2	32
27 births		69 children
By his second wife:		
6	× 2	12
2	× 3	6
8 births		18 children

Thus in thirty-five births by his two wives he had eighty-seven children of whom eighty-four are said to have lived to maturity. Other cases of remarkable series of multiple births are given by Miss Bell, some of them showing a tendency to twins and triplets for several generations. Several of these pedigrees suggest the inheritance of a twinning tendency in the male line as have other pedigrees published elsewhere.

When attempts to verify contemporary accounts are disappointing we are probably justified in accepting with a grain of salt Aristotle's account of an Egyptian woman who had four sets of quintuplets. Perhaps even in those ancient days it might have turned out on closer inquiry that the twenty children in question had a good many more than four birthdays among them—that even the Egyptians of two thousand years ago were not averse to their little "journalistic jokes" for the benefit of those whose will to believe outran somewhat their critical faculty—and in those days before the invention of the post office the difficulties of obtaining first hand verification were very great.

Living Quintuplets

Coincidences *do* occur, and the arrival of the Dionne quintuplets in Canada while the above article was being set in type is perhaps a demonstration of that fact. At the present time the quintuplets are being kept under strict quarantine to avoid infection and we have therefore been unable to obtain any first-hand information regarding them. However, arrangements have been made to get, as soon as possible, information regarding their fingerprints, blood-groups, etc. The fact that all are of one sex suggests that they may be identical, for were all derived from different eggs the odds are 32 to 1 that one would have been a boy.

In the photograph published herewith (Figure 5) the babies seem rather larger than one would expect considering that the heaviest one weighed 3¼ lbs. at birth. The photograph appears however to be unquestionably genuine, as photographs received subsequently and information direct from Canada leave little doubt that the case is authentic. Newspaper reports on June 7 of the birth of twins to a cousin of Mrs. Dionne suggest that a tendency to multiple births exists in this family,—or that more coincidences are at work.

ROBERT COOK.

A MUTATIONAL THEORY OF CANCER

(*Continued from page* 190)

mutation in mammals. His review of the literature is carefully done and reflects the results of extensive reading and academic study rather than first-hand contact with genetic experiments with laboratory mammals.

To introduce the idea of somatic mutation to the medical profession, his book should serve a useful purpose. It contains a minimum of detailed and necessarily boring genetic data. The subject is treated in a way calculated to convince those who approach it from a clinical point of view.

To a biologist it will not perhaps make as successful an intellectual appeal. The superficial treatment which served a useful purpose to the more general reader will be noted. Since, however, the book makes no pretext of being a monograph on the subject, and since geneticists themselves have been somewhat outstanding in their dereliction as writers of more or less popularly presented analyses of the problems of applied genetic principles, they cannot afford to be too critical of Lockhart-Mummery's effort.

The impression of the book retained by the majority of its readers will, without doubt, be more beneficial to the advancement of cancer research than it will be deleterious.

Over-interpretations or too high a degree of theorizing will, in all probability, be overlooked. The general attitude remaining will be that synthesis of many phases of the cancer research problem by the theory of somatic mutation is helpful and worth while.

C. C. LITTLE
Jackson Memorial Laboratory

INHERITANCE IN TOY GRIFFONS

C. C. Little
Jackson Memorial Laboratory, Bar Harbor, Maine

In "Pure-Bred Dogs," the official publication of the American Kennel Club which recognizes the standards of various varieties of dogs, are listed three types of Toy Griffons. These are Brussels Griffons, Belgian Griffons, and Little Brabançons. Of these, the two first named are rough-coated, while the last named is short-coated.

The description of Brussels Griffons is listed in part as:

"Coat: Reddish-brown, a little black at the whiskers and chin is allowable. The coat should be wiry, shaggy, or medium length and dense.

"Eyes: Very large, black and well open.

"Nose: Always very black.

"Nails: Black."

It is clear from the above that this breed is intended to be homozygous for the black-producing factor, *B* (Little[3]).

Belgian Griffons are described as follows:

"The characteristics of the Belgian Griffons are the same as those of the Brussels Griffon with this difference that for this breed the only colors admissible are (a) black (b) black and light brown (c) black and reddish brown mixed."

Little Brabançons are described as follows:

"The characteristics of the Little Brabançons are the same as those of the Brussels Griffon with this difference that this breed has a short coat, the only colors permissible are reddish brown and black and light brown. A black face is not a fault."

Material and Results

As parental animals a single pair of rough-coated Belgian or Brussels Griffons registered in the German Kennel Club was obtained by purchase at the Berlin Dog Show in 1930. These animals were sibs and litter mates. In color they were pale reddish brown with black eyes, nose and toe nails. The progeny representing four litters from this pair, totaling eleven animals, have given enough material to indicate a definite genetic relationship of various color varieties, hair lengths and tail characters.

Of the eleven progeny, eight have been rough-haired and three smooth-haired. This is a close approximation to a mendelian monohybrid ratio in which R^H, rough coat, is dominant and R, smooth coat, is recessive.

Griffons are a breed which the standard demands shall be bobbed-tailed. In the material reported there are animals which are naturally short-tailed as well as long-tailed animals (T). It is impossible to tell whether the two individuals originally acquired by purchase are both genetically short-tailed (T^S). It is probable, however, that one was short-tailed, T^ST, and one normal tailed TT. Of their progeny, six have been short-tailed and five long-tailed. The short-tailed animals have varied from those with a minute stub which required no docking to tails approximately half the full length. There has also been a considerable degree of distortion in the short tails. There is reason to believe this is a characteristic of that condition itself, and is not to be confused genetically with tail kinks which occasionally are encountered in long-tailed breeds.

Of the eleven progeny, six have been at birth a very dark brindle with ticked hair resembling closely the agouti pattern found in many types of domesticated rodents. Four were black with tan or reddish brown spots occurring in the location characterized by the

familiar pattern "black and tan." One was a pale lemon yellow and only survived for a very short period. All of the rough-coated dark brindles that lived to maturity turned out to be colored like the parents. During their development they underwent interesting changes becoming progressively lighter at apparently a steady and gradual rate. These animals are, in all probability, heterozygotes for a gene restricting black pigment. They exhibit a developmental behavior analogous to that of many "sable" mice which are very dark when young, and which become progressively lighter with increasing age until the adult condition is reached.

Haldane[2] has considered the yellow-producing gene in short-haired Dachshunds homologous with A^Y. This terminology is the simplest one to use as a working hypothesis. It supposes that the ticked coat pattern of the wolf is homologous with A agouti. The fact that in Dachshunds black and tan has been reported as being recessive to self black has caused Haldane to consider that it is not comparable with the same pattern a^t in rodents. In Griffons, however, there is no evidence which conflicts with its being placed in an allelomorphic series with A^Y. Until such evidence is obtained, the simplest interpretation of the black and tan pattern is to place it in that relationship with dominant yellow and with agouti. The situation in Dachshunds may involve the presence of an additional intensifier of black which Haldane recognizes as being present in the dog. There is no evidence of this gene in Griffons.

The six young which were dark agouti at birth and which became progressively lighter to reach an adult color of reddish tan would then be $A^Y a^t$ in constitution. The four black and tans would represent $a^t a^t$ animals. The one pale yellow which died soon after birth may possibly have been an $A^Y A^Y$ individual. If so, the action of the $A^Y A^Y$ combination may well be lethal or semi-lethal. Precedent for this condition exists in the case of several genes of a restrictive nature in rodents.

An interesting difference occurs in coat color between rough and smooth-coated varities of similar genetic constitution. In the latter, $A^Y a^t$ animals are rich reddish tan with black streaks producing the same general effect as a dark sable mouse. In the rough-coated animals of the same constitution (A^Y-a^t), the yellow pigments appear to be much attenuated with the result that the tan areas are much paler and the black streaks in the coat have almost disappeared. In $a^t a^t$ animals (black and tan), the short-haired individuals have deep glossy black ground color with rich reddish tan spots. The rough-haired $a^t a^t$ individuals are deep dull black with pale tan spots.

It is of importance to note in this connection that long hair such as that seen in the variety of Dachshund of that type is recessive to short hair and has no visible diluting effect on pigmentation.* In other words, $A^Y a^t HH$ (long haired) Dachshunds are often deep reddish tan in color while $a^t a^t HH$ black and tan long-haired Dachshunds are as richly pigmented as are $a^t a^t H^s H^s$ (short-haired) individuals.

It is not known whether the A^Y factor in Dachshunds is homologous with that in griffons. There is, however,

*The terminology for hair length genes is somewhat complicated. As a general thing an effort has been made to designate the genes characterizing the wild type by simple capital letters. The varieties of dogs closest to the wolf, as well as the wolf itself, are not typically short-haired. If therefore, we consider the primitive or wild long-haired type in dogs as H, the short-haired type which is dominant might be designated by H^S. The increased length of hair seen in the wirehaired or rough coated breeds offers a further complication. It is dominant to short hair. It cannot therefore be due to the same gene that produces increased hair length in the wild type of dog. Since in Wright's terminology R and in Haldane's R^O are used to designate the dominant roan pattern, the symbol R^H may be employed to describe wire (rough) hair and R to designate non-wire hair (smooth).

reason to believe that it probably is. The relation of these tan varieties to the coat color of the Irish Terrier is not clear. Superficially the coat color of the paler types of Irish Terriers is very similar to that of the Brussels Griffon.

Since, however, there seems to be no evidence that in Irish Terriers, the A^Y factor is itself lethal, it may be that linked balanced lethals are involved.* Of course the lethal action of A^Y in griffons and in Dachshunds cannot be considered as demonstrated. It is, however striking that it appears to be very hard to obtain true breeding tan A^Y animals in both of those breeds. Further genetic studies of these color varieties would be of great interest.

Summary

In toy griffons the following genetic factors appear to be found:

B: A gene producing black pigmentation;

A^Y: A gene restricting the distribution of black pigment; dominance of this over a^t is incomplete.

a^t: Its allelomorph allowing the extension of black pigment to form a black and tan pattern.

R^H: A gene producing a rough wiry coat;

R: Its allelomorph producing a smooth coat;

T^s: A gene producing short tail;

T: Its allelomorph producing normal tail length.

Literature Cited

1. American Kennel Club, *Pure-Bred Dogs*, G. Howard Watt, New York. 1929.
2. Haldane, J. B. S., *Biol. Reviews*, 2. 1927.
3. Little, C. C., *Journ. Hered.* 5. 1914.
4. Little, C. C., and E. E. Jones, *Journ. Hered.* 10. 1919.
5. Wright, S., *Journ. Hered.* 9. 1918.

Errata In March Journal

In Figure 6 (page 87) of Dr. Blakeslee's article the right half of the 9·10 chromosome lacks the vertical hatching which is shown on the left half. This chromosome is correctly represented in Figure 5 on the opposite page. This oversight is regretable because it may cause the 9·10 and the 19·20 chromosomes to be confused.

On page 85, in the same article the eighth and ninth lines below the subhead ("How Extra-Chromosomal Types are Obtained") in the right hand column are transposed. The sentence in which these lines are included should read: "A $4n$ plant, crossed with a normal $2n$, produces $3n$ offspring. The latter crossed with a normal produces all the primary $2n + 1$ types . . . . ."

Relief Families Larger than Average

The study of chronically dependent families from the records of the Los Angeles Welfare Bureau has been completed for publication. It shows that the average size of family born of these indigents, all of whom have been on the county relief rolls for at least five years, consists of five living children.

Annual Report of the Secretary of the Human Betterment Foundation.

*The case would then be analogous with the behavior of short-tail T^s in mice. In certain stocks short tail by short tail gives a ratio of two short tails to one normal. In others, true breeding short tails which however give a one to one ratio when back-crossed with normals, are obtained.

A NEW TECHNIQUE IN COTTON HYBRIDIZING

Suggested Changes in Existing Methods of Emasculating and Bagging Cotton Flowers

CLIFTON C. DOAK

Agricultural and Mechanical College of Texas

EMASCULATION partakes of a mutilating operation which unavoidably creates unnatural conditions. Although we realize that a technique which is rapid and sure and at the same time entirely free from physiologic and genetic uncertainties, is impossible of attainment; nevertheless, we should not be content with a method containing correctable faults. Our enumeration of the objections to the method in present use in cotton work is not intended to cast reflections on cotton workers as a class but rather to emphasize the points in their technique toward which we may direct efforts toward improvement.

The first of these objections is that the method is unduly difficult. While making the emasculations, several instruments must be cared for and approximately a hundred closely pressed anthers (Figure 7) tediously removed. After emasculation, a cumbersome bag is tied over a relatively small flower.

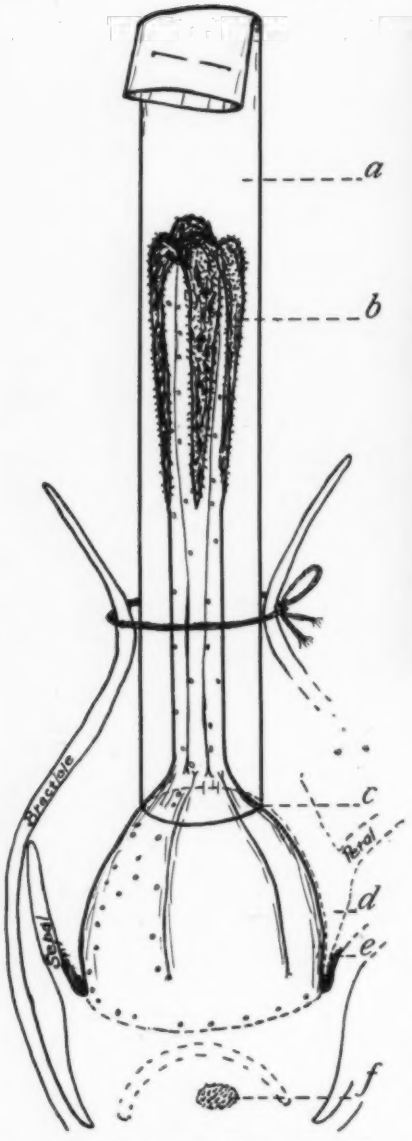
At present a cotton breeder carries all or most of the following equipment: pencil for recording, tags for labeling, bags for covering, string or paper clips for securing the bags in place, scissors or forceps for removing the anthers, and a bottle of alcohol for disinfecting hands and instruments. The handling of instruments under field conditions is at best an awkward procedure, and the difficulties are multiplied as the number of needed tools is increased; therefore, any reduction in the essential equipment would simplify the problem and prove greatly desirable.

From the standpoint of physiology, the method in present use is also far from perfect, for each severed filament adds its bit of wound tissue to that left by the previous excision of the petals (Figure 8*E*). The covering bag exposes a relatively large area to the wind, which, in whipping it about may injure the peduncle of the bagged flower. Paper bags exclude the light and, of course, stop photosynthesis in the bractioles of the involucre, which, as Kearney* has shown, serve the subtended boll in important nutritive and protective capacities.

Technical workers in cotton have sought to overcome the objections to the opaque bag by substituting a translucent one of "cellophane" or waxed paper ("Glassene"). These, however, introduce more objectionable features than they correct, for they not only interfere with free gaseous interchange but retain transpired water. Even in bright sunlight, the air within such a bag precipitates droplets of water which act as minute burning glasses and thus bring about scalding of tissues.

From the standpoint of genetic pu-

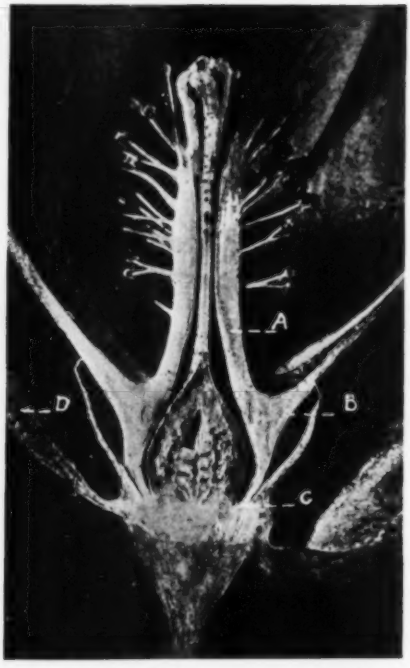
*Kearney, Thomas W. Development of cotton bolls as affected by the removal of the involucre. *Jour. Agr. Res.* 38:381-393, 1929.



THE SODA STRAW IN PLACE

Figure 6

Enlarged drawing showing the soda straw (*a*) in place over the stigma (*b*). When pressed tightly against the ovary (*c*) the straw completely excludes even small insects from the stigma. The nectaries (*e* and *f*) are outside the straw.



CROSS SECTION OF A COTTON FLOWER

Figure 7

The staminal column surrounds the slender stigma. This column is attached to the corolla (*b*) and the weakest point in this combined structure is at its attachment (*c*). The bractioles (*d*) surround the flower bud and later the developing boll. Modified—after Lawrence Balls.

rity of the resulting plants, the method now in use is open to additional objections. In removing the anthers, there is danger of crushing some of them and of spilling pollen over flower parts and instruments. These dangers can be reduced by frequent sterilization of hands and instruments, nevertheless, the possibility of crushed anthers introduces an element of uncertainty which even the most indifferent worker would be glad to see eliminated. Falling anthers may lodge unnoticed in the calyx cup or in some other of the numerous hidden places about the flower (Figure 7), and their

A NEW TECHNIQUE OF EMASCULATING COTTON FLOWERS

Figure 8

The usual method of emasculating cotton flowers is by the laborious removal of the individual stamens as shown at (*E*). The emasculated flower is then bagged to protect it from insects. The technique described here removes the entire staminal column and corolla in one piece (*A*). Flowers after the removal of the corolla are shown at *B* and *C*. An emasculated flower with a soda straw fitted over the stigma is shown at *E*, with the straw held in place by a paper clip on the bractioles. It is found that this form of protection is quite efficient in practice and offers a number of advantages over the more cumbersome method of removing the stamens and bagging the flowers.

unwanted pollen may later reach the stigmas.

During the summer of 1932, efforts were made to correct some of these faults by adapting the *Datura* technique of Buchholz and Blakeslee* to the cotton plant. The technique described below is the result of those efforts.

Cotton has a typically malvaceous

*The technique here referred to is in regular use at The Station For Experimental Evolution at Cold Spring Harbor, Long Island, New York.

flower with filaments united to form a staminal column; this is in turn adnate to the corolla (Figure 7*B*). These parts differ radically from corresponding parts in the jimson weed, *Datura*. It was found impossible, therefore, to adopt the *Datura* method for use in cotton work without several modifications. The substitution of the fingers for the instruments in the removal of the anthers from the filaments as is done in *Datura* work proved impracticable. Study of the floral anatomy of cotton, however, revealed the fact that one can slit the tender staminal column (Figure 7*A*) with the fingernail, after which it is possible to grasp one of the adjacent petals and pull off the entire corolla and androecium in a single piece (Figure 8*A*). The weakest point in this common structure is at its very thin insertion (Figure 7*C*). It is at this point that the absciss layer forms in normal shedding of flower parts. It is at this point also that the parts can be removed with a minimum of resulting wound tissue. After removal of corolla and androecium, the pistil is left intact and yet completely exposed for pollination (Figure 8*B*) or for other experimental procedures. This method requires no forceps or scissors and, when skillfully done, does not expose the anthers to crushing. It leaves the stigmatic surfaces untouched and has the additional advantage of leaving no falling anthers to be accidentally lodged about the treated flower.

After emasculation, a short section of soda straw which has been previously closed at one end is placed over the stigma and style (Figure 8*D*, and Figure 6*a*). The bractioles are then secured around it by means of paper clips (Figure 8*D*) or with string (Figure 6). There is no bag to catch wind, nor to imprison transpired water, nor to shut out the light and gases needed in the photosynthetic work of the leaflike bractioles. When fitted tightly against the ovary (Figure 6*c*), the straw completely excludes small insects which might either be enclosed in a bag or which might, in their attempts to reach the nectaries, find their way in between the numerous folds of the bag. Small ants are frequent visitors to the nectaries of cotton. They reach the flower by crawling along the pedicle. They thus meet the paper barrier at its most vulnerable point. The soda straw, when substituted for the bag, has the advantages of leaving the nectaries fully exposed so that, while visiting them, insects may come and go without endangering the stigmas (Figures 6*e* and 6*f*.)

When measured by the number of sets obtained, the new method proves to be as good as, or better than, the old. Mr. F. O. Beasley*, Technical Assistant in Cotton Breeding at the Texas Agricultural Experiment Station, was so well pleased with the results obtained from tests made early in the season of 1933 (85 per cent sets June 25) that he adopted the method as a regular part of his field technique and now has a large number of mature bolls to testify to its success.

Summary

A method of emasculating cotton flowers by removal of corolla and androecium in a single piece is here described. This technique, when combined with the substitution of a soda straw for the customary paper bag, can claim the advantages of being faster and simpler, as well as physiologically and genetically less objectionable, than the method now in use.

*Mr. Beasley is working under the direction of Dr. D. T. Killough, Agronomist in charge of cotton breeding for the Texas Station. Mr. Killough has shown a sincere interest in the problem from its beginning. He furnished the plants for the experiment, for which acknowledgment is gratefully made.

CREEPER AND SINGLE-COMB LINKAGE IN THE FOWL

LEWIS W. TAYLOR

University of California, Berkeley.

THE paper by Serebrovsky and Petrov,[3] reporting autosomal linkage with approximately eight per cent crossing over between the Creeper gene and the single-comb allelomorph of the gene for rose-comb, led the late Dr. W. A. Lippincott and the writer to initiate linkage tests for these characters. Single-comb Creeper stock had been previously obtained from Mrs. Kate Berry of Duarte, California, through the aid of Mr. George W. Masterson. No record of the original source of this stock was available. The Creeper fowls were of two color patterns: one typical of that of the Ancona, the other a buffish type evidencing crossbred origin. Crossbred stock from an original mating of Silver Spangled Hamburg × Black Minorca was used to furnish the rose-comb character.

The rose-comb normal and single-comb Creeper stock were first crossed in 1929, and the first linkage tests by backcrosses of the F_1 to single-comb White Leghorns were made in 1930. During these years the chicks produced were classified as Creeper or normal on the basis of the gross appearance of the legs. In a total of 198 chicks and embryos from F_1 rose-comb Creeper male D99, eight crossovers were recorded. There were also eight crossovers in a total of 501 chicks and embryos from six F_1 rose-comb Creeper females. The crossover values were 4.04% and 1.60% respectively.

Of the 16 crossover chicks obtained, 13 were single-comb normals and only 3 rose-comb Creepers. Normally, equality in numbers would be expected. The excess of single-comb normals was similar to that obtained by Serebrovsky and Petrov,[4] who reported 33 crossovers in a total of 328 individuals, 24 being single-comb normals and nine rose-comb Creepers.

Further matings were made with additional F_1 birds in 1931. All chicks and embryos not readily classified by gross appearance were dissected and the structure of the tibiae and fibulae was examined. The excellent description of the morphology of the Creeper condition by Landauer[1] served as a guide in identifying the Creeper chicks. A tendency to confuse a type of single-comb Creeper, which had legs intermediate in length between the usual Creeper and the normal, with the single-comb normal chick was discovered. Hence, the crossover values of 1930 doubtless were too high to represent the true condition, since more single-comb normal chicks were probably recorded than actually were present.

In 1931 (Tables I and II) a much lower proportion of chicks in crossover classes was produced than recorded in 1930. In all, 4 single-comb normal and 6 rose-comb Creeper chicks were found, or approximate equality in the crossover classes. The crossover values were 0.59% for the females and 0.40% for the males. These values corresponded closely to data obtained by Landauer,[2] who reported corresponding values to be 0.57% and 0.13% based on 3,532 and 3,095 chicks, respectively.*

In our tests the percentage of cross-

*Landauer has recently reported 0.38 per cent crossing-over on 781 offspring obtained in the third laying year of heterozygous rosé-comb Creeper hens. (*Nature* 132:606;1933).

ing over was slightly lower in the males than in the females, but not to such a pronounced degree as found by Landauer. It is interesting to note that the highest values of crossing over were obtained from yearling females and two-year-old males. Landauer found lower values for both sexes in the second year, but questioned its significance. In this work, as in Landauer's, insufficient data are available to prove the significance of the differences.

In our matings it is unlikely that any marked degree of lethality was associated with chicks in the crossover classes. The unclassified early embryonic mortality was 10.2% in embryos from the Creeper males and 8.3% from the Creeper females. The losses are low and compare favorably with mortality in embryos from normal stock. Hence, the proportions of crossovers found in the chicks classified probably represent the true values for the genes involved.

Landauer considered the difference between his results and those of Serebrovsky and Petrov to have been produced by genetic differences in the stock used. Our experience would suggest that the differences might rest in part with the method of identification of the Creeper condition. This view is supported by the similarity between the considerable excess of single-comb normal chicks over rose-comb Creeper chicks in our 1930 results, which we later found to be due to an inaccurate classification of the Creeper condition, and a corresponding excess in the data reported by Serebrovsky and Petrov.[4]

TABLE I.—Crossing Over in Creeper Females (1931)

Creeper Female	Early embryonic deaths	Rose creeper	Rose normal	Single creeper	Single normal	Per cent crossing over
D783	2	—	8	16	—	0.00
D784	6	—	10	17	—	0.00
D785	8	—	37	33	—	0.00
D787	3	1	25	30	—	1.79
D788	3	1	5	16	—	4.55
D789	1	1	40	31	—	1.39
All yearling hens	**23**	**3**	**125**	**143**	**0**	**1.11**
D848	9	—	43	61	—	0.00
D871	14	—	50	62	—	0.00
D874	—	—	16	23	—	0.00
D931	5	—	19	25	—	0.00
D980	11	1	61	51	—	0.88
All two-year-old-hens	**39**	**+**	**189**	**222**	**0**	**0.24**
All females	62	4	314	365	0	0.59

TABLE II.—Crossing Over in Creeper Males (1931)

Creeper Male	Early embryonic deaths	Rose creeper	Rose normal	Single creeper	Single normal	Per cent crossing over
E58	27	—	151	191	2	0.58
E60	13	—	124	111	—	0.00
E61	53	—	106	97	—	0.00
E63	12	—	59	70	—	0.00
All yearling males	**105**	**0**	**440**	**469**	**2**	**0.22**
D99	42	2	220	187	1	0.73
D151	23	—	95	83	1	0.56
All two-year-old-males	**65**	**2**	**315**	**270**	**2**	**0.68**
All males	170	2	755	739	4	0.40

Summary

Data obtained on linkage between the single-comb allelomorph for rose-comb and the Creeper condition in the chicken confirm Landauer's results indicating an average crossover value of close to or less than 0.5%. Gross appearance of the leg did not serve as an accurate means of classifying a comparatively long-legged type of Creeper and, when used, gave materially higher crossover values.

L'terature Cited

1. Landauer, W., 1931. Untersuchungen über das Krüperhuhn. II. Morphologie und Histologie des Skelets, insbesondere des Skelets der langen Extremitätenknochen. *Z. mikr.-anat. Forsch.* 25:115-180.

2. ————————, 1932. Studies on the Creeper fowl. IV. The linkage of the genes for Creeper and single-comb. *Jour. Gen.* 26: 285-290.

3. Serebrovsky, A. S. and S. G. Petrov, 1928. A case of close autosomal linkage in the fowl. *Jour. Hered.* 19:305-306.

4. ———————— ————————, 1930. "The topography of the chromosomes of the domestic fowl." (Russian.) *Jour. Exp. Biol.* 6:157-179. (From translation by Miss Glessing, U. S. Dept. Agr.)

A Glossary Of Genetic Terms

GENETICS has developed so rapidly that many terms in common use in genetic literature are not yet incorporated in the dictionaries. Many people who are interested in heredity are bothered by such words, for which no definition can conveniently be found. For this reason, it is proposed to publish occasionally a glossary of terms which would not be readily understood and which are not to be found except in new unabridged dictionaries. It is realized that these definitions will probably not meet with universal approval and comments and suggestions will be welcomed.

ALLELOMORPH—Mendelian characters are inherited in alternative pairs, or in alternative series. These alternative genes are called allelomorphs. Examples: Albinism (recessive), Normal pigmentation (dominant); Horns (recessive), Hornlessness (dominant).

BACKCROSS—Cross of a hybrid to one of the parental forms.

CHARACTER (a contraction of characteristic)—A term used, often rather vaguely, to designate any form, function, or feature of an organism. The Mendelian characters of genetics represent the end-products of development in which a definite gene, or genes, have a decisive effect. "The constant and unchanging thing, therefore, is the factor (gene) itself rather than the character, and the unity which Mendel observed lies rather in this underlying factor than in the visible, and perhaps variable, character which it produces."—Sinnott and Dunn.

CHROMOSOMES—Tiny dark-staining bodies visible in the nucleus of the cell at the time of cell-division. The number of chromosomes in any species is usually constant. The chromosomes carry the genes, linearly arranged, which control the development of Mendelian characters.

CONJUGATION—Side-by-side association of homologous chromosomes previous to formation of genetics.

DOMINANT—A character possessed by one of the parents of a hybrid, which appears in the hybrid to the exclusion of the contrasted character from the other parent (the recessive). Thus in a cross of green- and yellow-seeded peas the first generation has yellow seeds. Yellow is dominant and green is recessive, being transmitted but not appearing in the presence of the factor for yellow.

FACTOR—Same as *Gene*.

F_1—(Pronounced eff-one). The first filial generation. The offspring of a given mating.

F_2—The second filial generation. Produced by intercrossing or self-fertilizing the F_1. The inbred grandchildren of a given mating.

GAMETE—A reproductive cell of either sex; e. g. sperm or ovum.

GENE—(1) The unit of inheritance, which is transmitted in the germ cells, and which by interaction with the genic and cytoplasmic complex controls the development of a character. The genes are arranged linearly in the chromosomes. (2) "The physical basis of heredity"—or more figuratively, the atom of the genetic molecule.

HETEROZYGOUS—Containing both genes of an allelomorphic pair, or two genes of an allelomorphic series. Heterozygous individuals generally resemble the individuals homozygous for the dominant character, but they transmit the recessive to half their offspring.

HOMOZYGOUS—(1) An organism formed by like germ cells; (2) An organism is said to be homozygous for a given character when all the germ cells transmit identical genes for this character. This is the most frequently used meaning of the term.

LINKAGE—Association of genes in inheritance, due to the fact that they are in the same chromosome.

MONOZYGOTIC—Originating from a single fertilized egg cell, which in the course of subsequent development has given rise (by fission) to two or more individuals. Twins (or triplets, etc.) of such origin are, barring mutations, genetically identical.

MUTATION—Where a heritable variation begins. A sudden variation in an inherited character.

POLYPLOID—Normal body cells of the higher plants and animals have two sets of chromosomes (see *Diploid*). Polyploids are forms having three or more of these basic chromosome sets.

RECESSIVE—See *Dominant*.

REDUCTION DIVISION—The division preceding the formation of gametes, in which the chromosome pairs separate, and the chromosome number is reduced to half the somatic number.

SEGREGATION—Separation of allelomorphic genes at meiosis.

SELFED—Self-pollinated.

SOMATIC—Referring to body tissues; having two sets of chromosomes, one set normally coming from the female parent and one from the male; as contrasted with germ cells having a single set of chromosomes.

TRIPLOID—An organism characterized by having three times the reduced primary chromosome number.

JOURNAL REPRINTS

A CHANGE in the method of making reprints has made available extra copies of reprints of some of the articles in recent numbers. While the supply lasts these may be obtained by members at the prices listed. The reprints are furnished in plain Krafft covers. Orders for ten or more copies of these reprints (of either the same or different titles) will be accepted at a 50 per cent discount from the quoted price. Stamps will be accepted in payment.

HEREDITARY RADIUM-INDUCED VARIATIONS IN THE TOMATO, by E. W. LINDSTROM 20c

TWINNING IN SEVEN GENERATIONS OF THE BERTOLET FAMILY, by S. B. DETWILER 10c

HOUND EARED MICE, by B. W. MCPHETERS and C. C. LITTLE 10c

A CHLOROPHYLL MUTATION IN WHEAT, by K. W. NEATBY 10c

EARLINESS AND SEASONAL GROWTH HABIT IN WHEAT, by H. H. MCKINNEY and W. J. SANDO 20c

DETERMINING SIMILARITY OF TRIPLETS AND QUADRUPLETS, by S. E. TORSTEN LUND 10c

INBREEDING BERKSHIRE SWINE, by E. E. HUGHES 15c

HYBRIDIZING DIAMOND-BACK TERRAPINS, by SAMUEL F. HILDEBRAND 15c

SYNDACTYLISM WITH VARIATIONS, by WINFIELD SCOTT 15c

INHERITANCE OF STAR IN DEER MICE, by ELIZABETH BARTO and R. R. HUESTIS 10c

CHROMOSOME BEHAVIOR IN A TRIPLOID TRADESCANTIA, by EDWARD KING 15c

INHERITANCE OF WAXY ENDOSPERM IN SORGHUM, by R. E. KARPER 15c

EDUCATION AND SIZE OF FAMILY, by NATHAN L. WHETTEN 10c

HERITABLE CHARACTERS IN MAIZE (NANA), by H. W. LI 10c

RECESSIVE COLORATION IN DUTCH BELTED CATTLE, by R. B. BECKER 10c

BUD VARIATION IN THE AGEN PRUNE, by A. D. SHAMEL, C. S. POMEROY, R. E. CARYL and F. N. HARMON 15c

LINKAGE TESTS IN POULTRY, by WALTER LANDAUER 10c

REACTION OF DOMINANT WHITE WITH YELLOW IN THE FOWL, by C. H. DANFORTH 15c

PSEUDOGAMY IN BLACKBERRY CROSSES, by G. M. DARROW and G. F. WALDO 10c

HERITABLE CHARACTERS IN MAIZE (LIGULELESS-2), by R. A. BRINK 10c

VON RECKLINGHAUSEN'S DISEASE, by ROBERT COOK 10c

HYBRIDS BETWEEN WHEAT AND COUCH GRASS, by S. VEL.SHKINE and A. SHECHURDINE 20c

A DWARF MUTATION IN KAFIR, by JOHN B. SIEGLINGER 10c

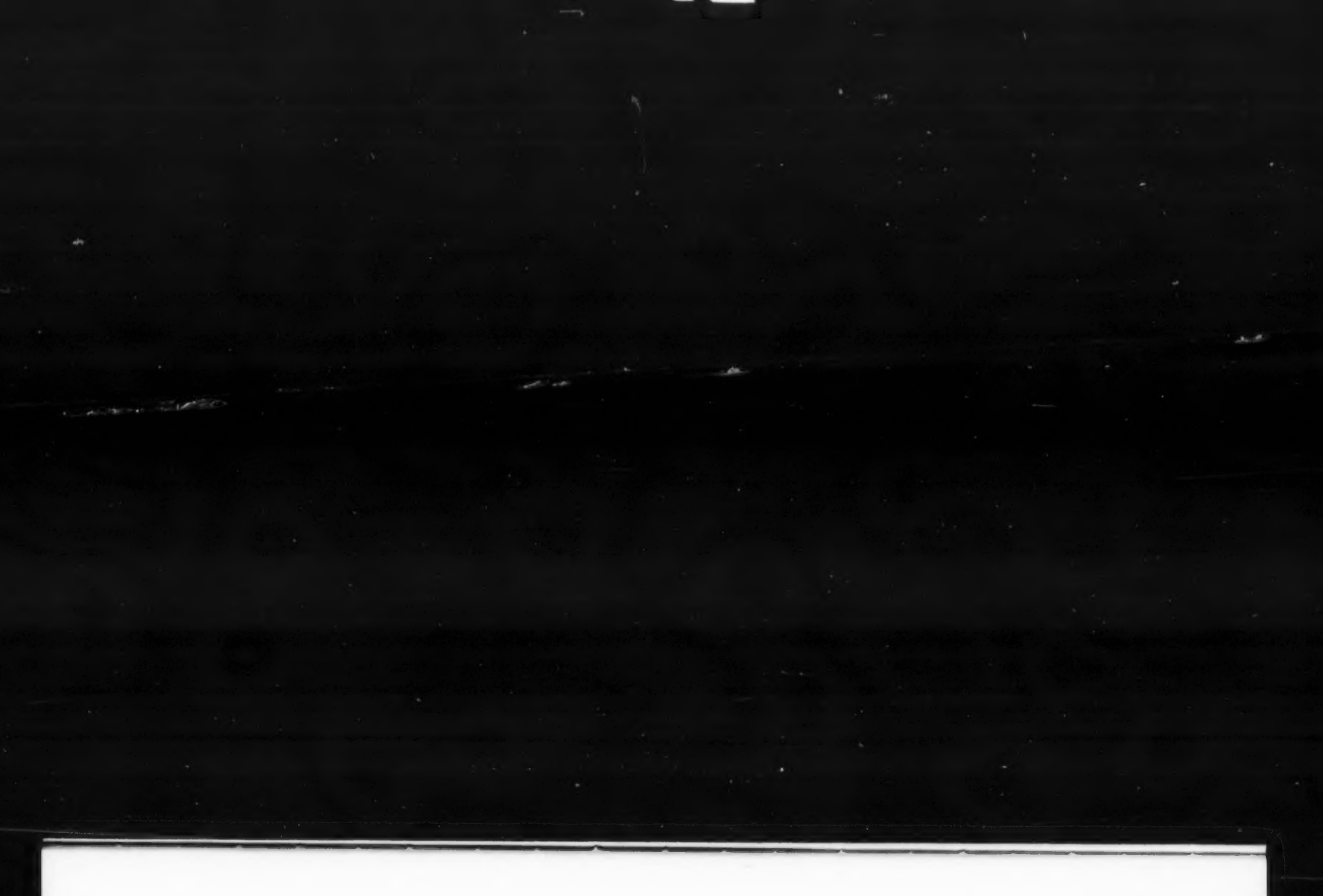
GENETIC STUDIES OF MONOZYGOTIC TWINS, by D. CECIL RIFE .. 15c

BUD POLLINATION IN CABBAGE, ETC., by Y. KAKIZAKI and T. KASAI 10c

INHERITANCE OF ALBINISM IN THE DOMESTIC FOWL, by D. C. WARREN 15c

LEFT-HANDEDNESS AND STUTTERING, by BRYNGELSON and THOMAS B. CLARK 15c

TWELVE YEARS OF STRAWBERRY BREEDING, by G. M. DARROW, G. F. WALDO and C. E. SCHUSTER 20c

A "STRANGLING" EUCALYPTUS, by MARY FRANCES BAKER 10c

GENETIC STUDIES OF MONOZYGOTIC TWINS, by D. CECIL RIFE .. 20c